FIG.1

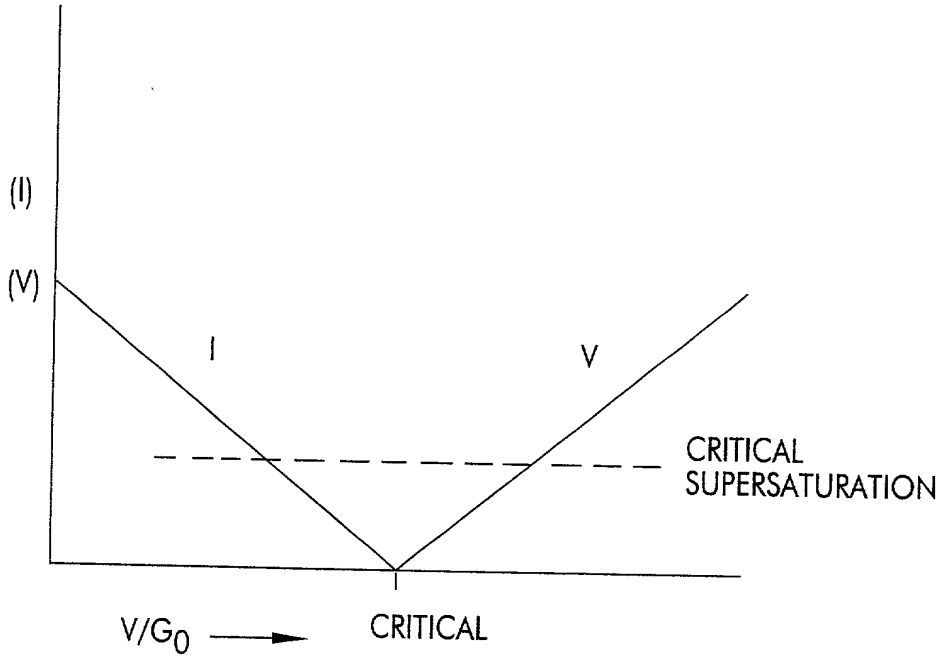

(I)
(V)
I
V
CRITICAL
SUPERSATURATION
V/G0
CRITICAL

FIG.2

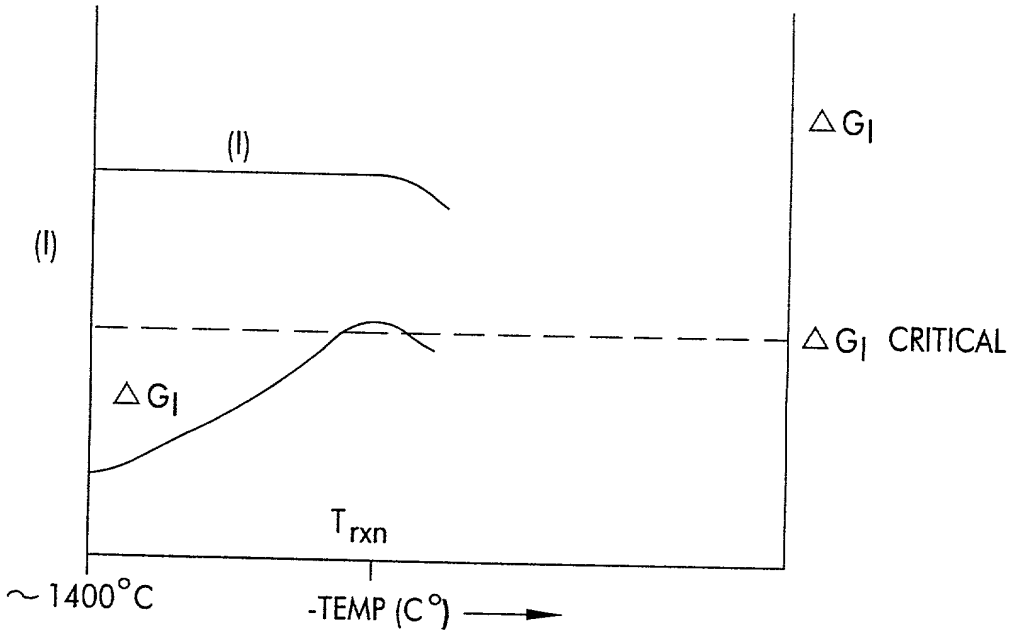

(I)
(I)
ΔGI
ΔGI CRITICAL
ΔGI
Trxn
~1400°C
-TEMP (C°)

FIG.3

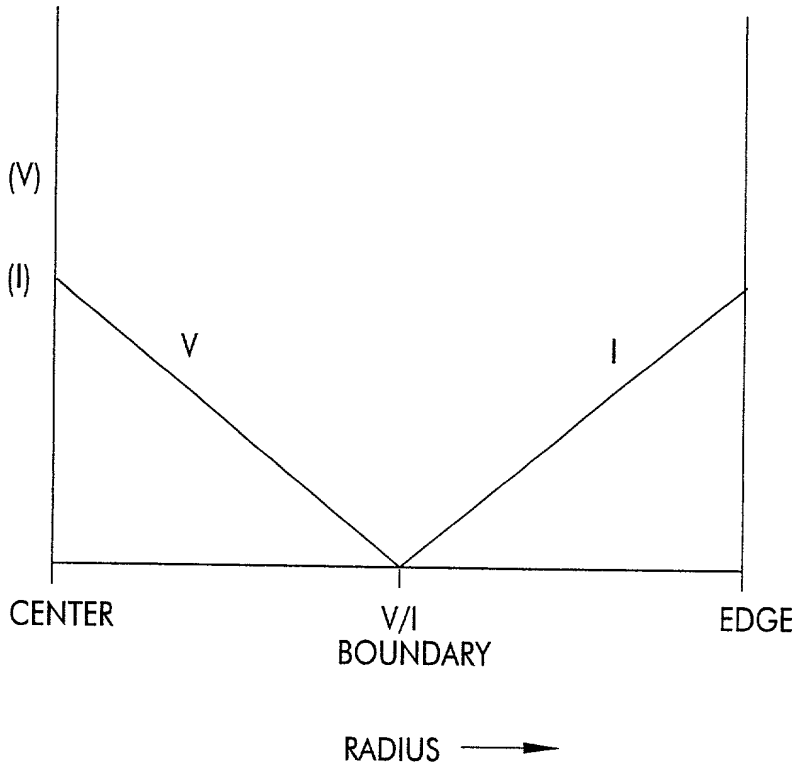

(V)
(I)
V
I
CENTER
V/I
BOUNDARY
EDGE
RADIUS

FIG.4

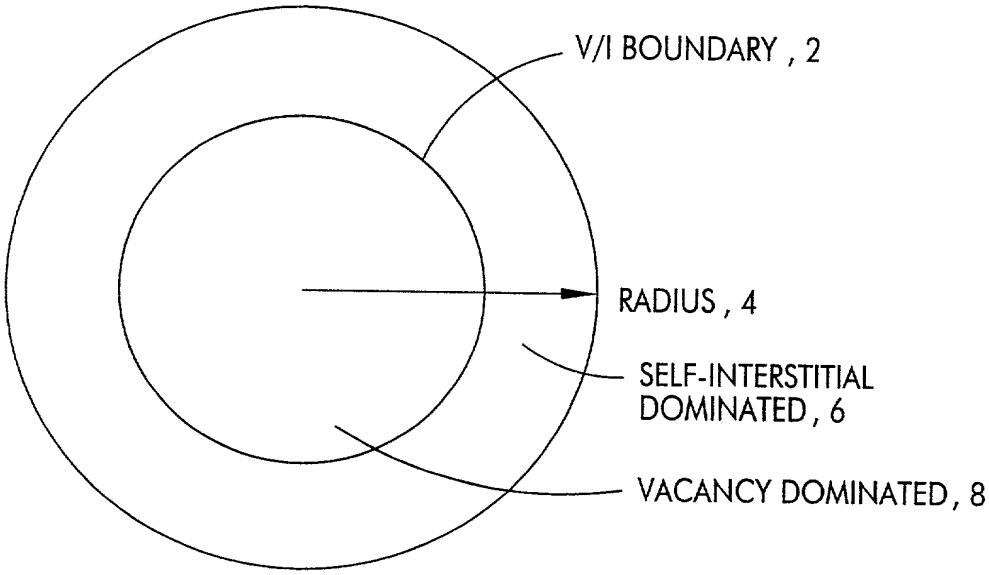

V/I BOUNDARY , 2
RADIUS , 4
SELF-INTERSTITIAL
DOMINATED , 6
VACANCY DOMINATED , 8

FIG.5

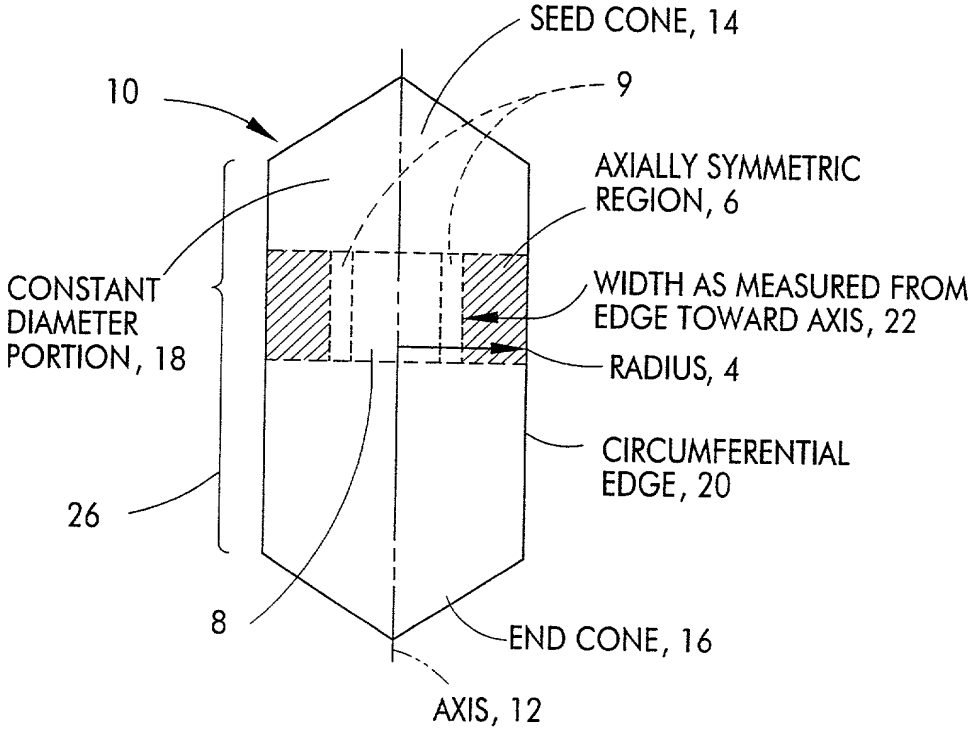
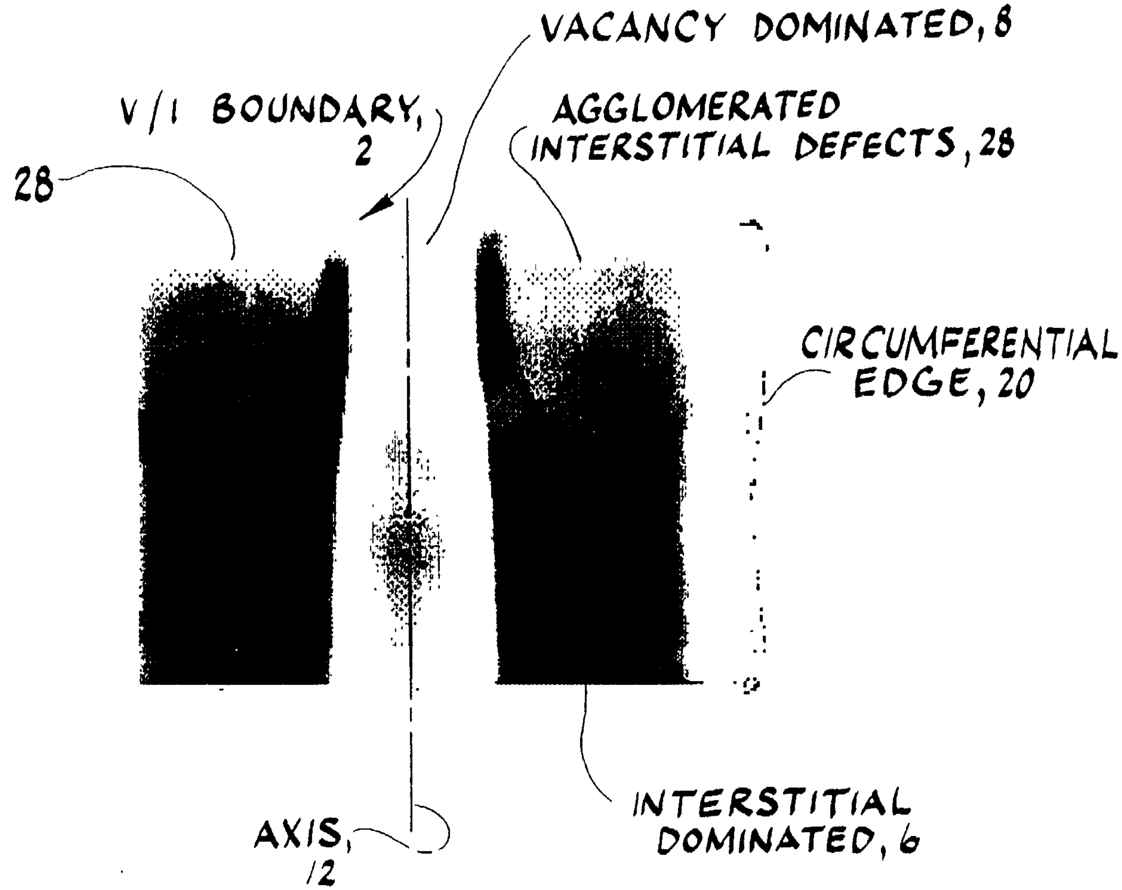

SEED CONE, 14
10
9
AXIALLY SYMMETRIC REGION, 6
CONSTANT DIAMETER PORTION, 18
WIDTH AS MEASURED FROM EDGE TOWARD AXIS, 22
RADIUS, 4
CIRCUMFERENTIAL EDGE, 20
26
8
END CONE, 16
AXIS, 12

FIG. 6


VACANCY DOMINATED, 8
V/I BOUNDARY, 2
AGGLOMERATED INTERSTITIAL DEFECTS, 28
28
CIRCUMFERENTIAL EDGE, 20
AXIS, 12
INTERSTITIAL DOMINATED, 6

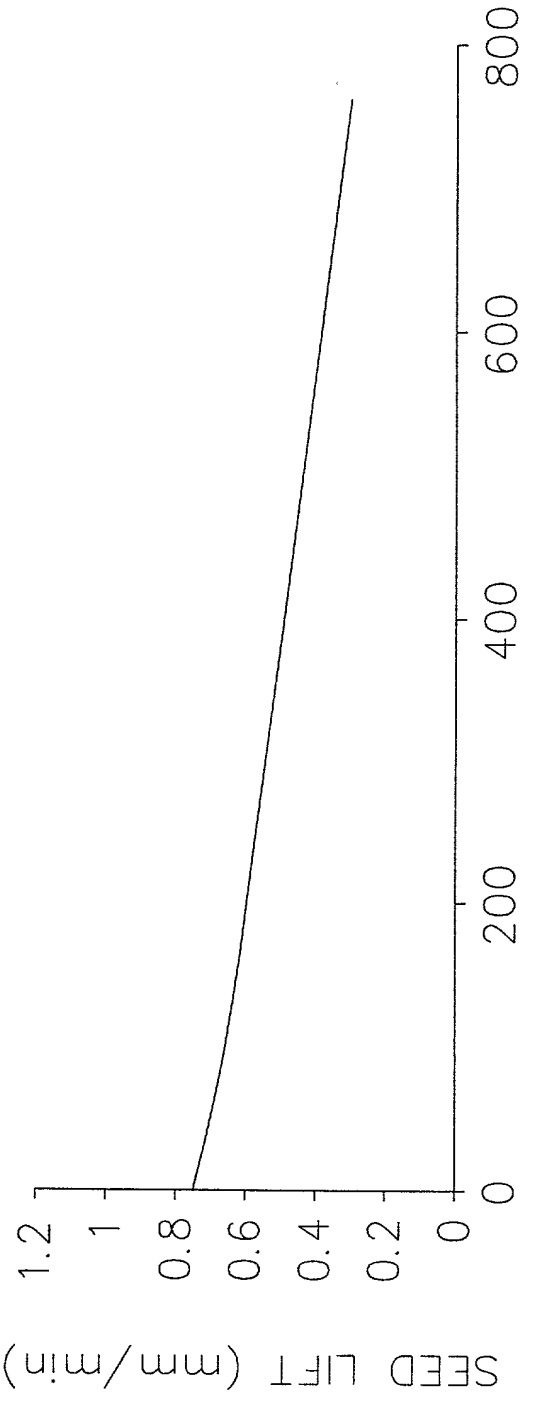


FIG. 7

FIG. 8

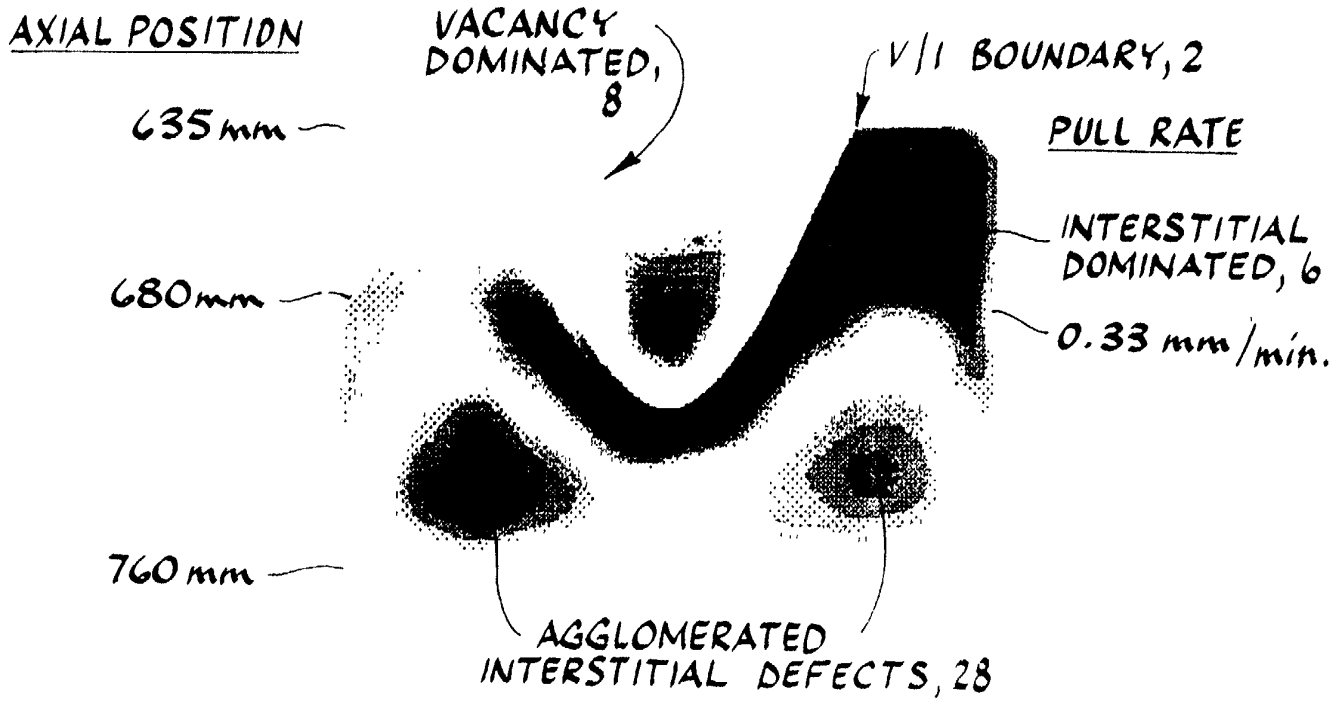

AXIAL POSITION
VACANCY DOMINATED, 8
V/I BOUNDARY, 2
635mm
PULL RATE
INTERSTITIAL DOMINATED, 6
680mm
0.33 mm/min.
760mm
AGGLOMERATED INTERSTITIAL DEFECTS, 28

FIG. 9

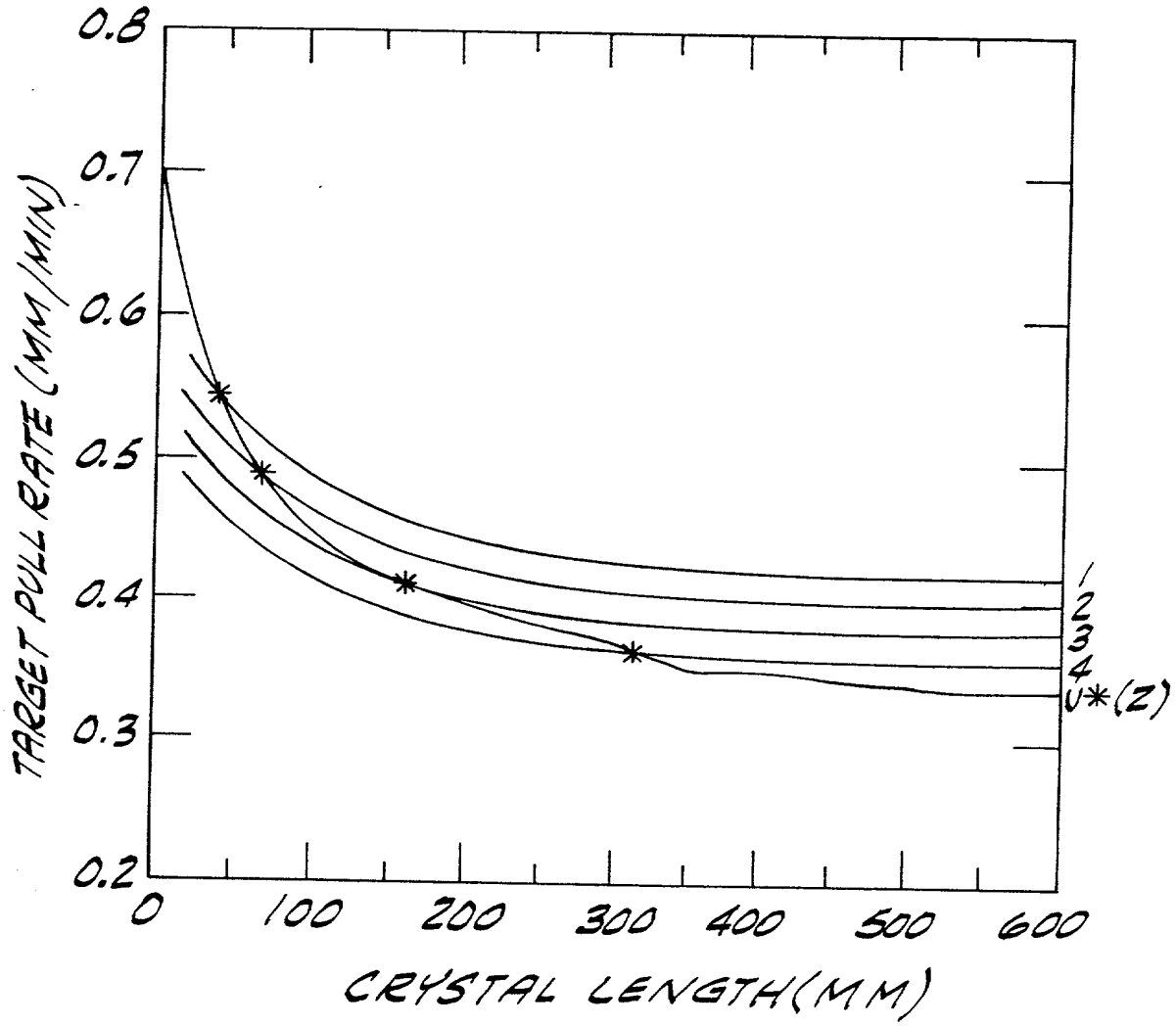

0.8
0.7
0.6
0.5
0.4
0.3
0.2
TARGET PULL RATE (MM/MIN)
0
100
200
300
400
500
600
CRYSTAL LENGTH(MM)
1
2
3
4
V*(Z)

FIG. 10

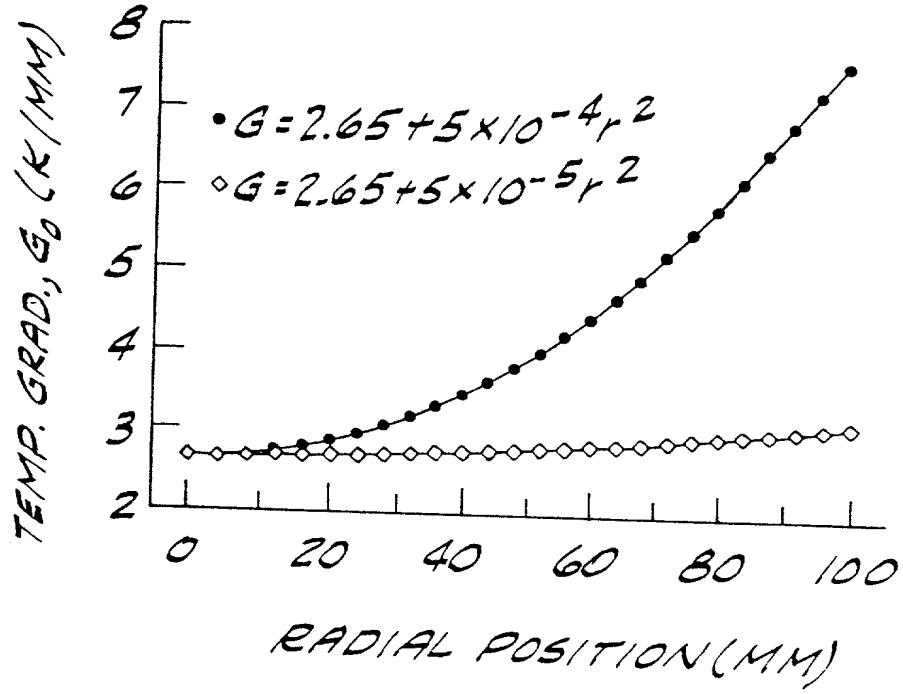

TEMP. GRAD., G_0 (K/MM)
• $G = 2.65 + 5 \times 10^{-4} r^2$
◇ $G = 2.65 + 5 \times 10^{-5} r^2$
8
7
6
5
4
3
2
0
20
40
60
80
100
RADIAL POSITION (MM)

FIG. 11

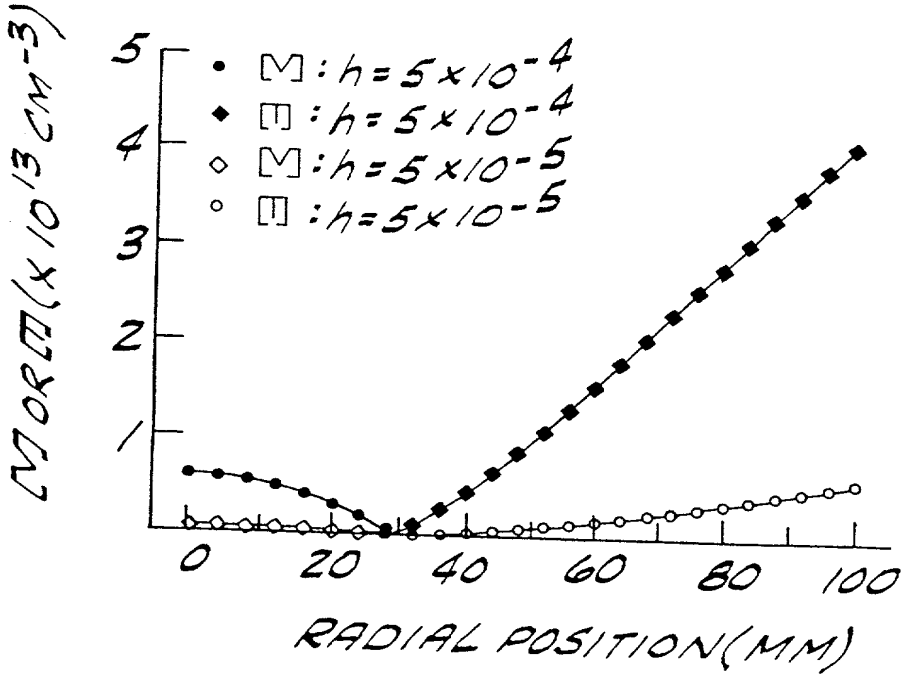

[M] OR [I] ($\times 10^{13}$ CM^{-3})
• [M] : $h = 5 \times 10^{-4}$
◆ [I] : $h = 5 \times 10^{-4}$
◇ [M] : $h = 5 \times 10^{-5}$
○ [I] : $h = 5 \times 10^{-5}$
5
4
3
2
1
0
20
40
60
80
100
RADIAL POSITION (MM)

FIG. 12

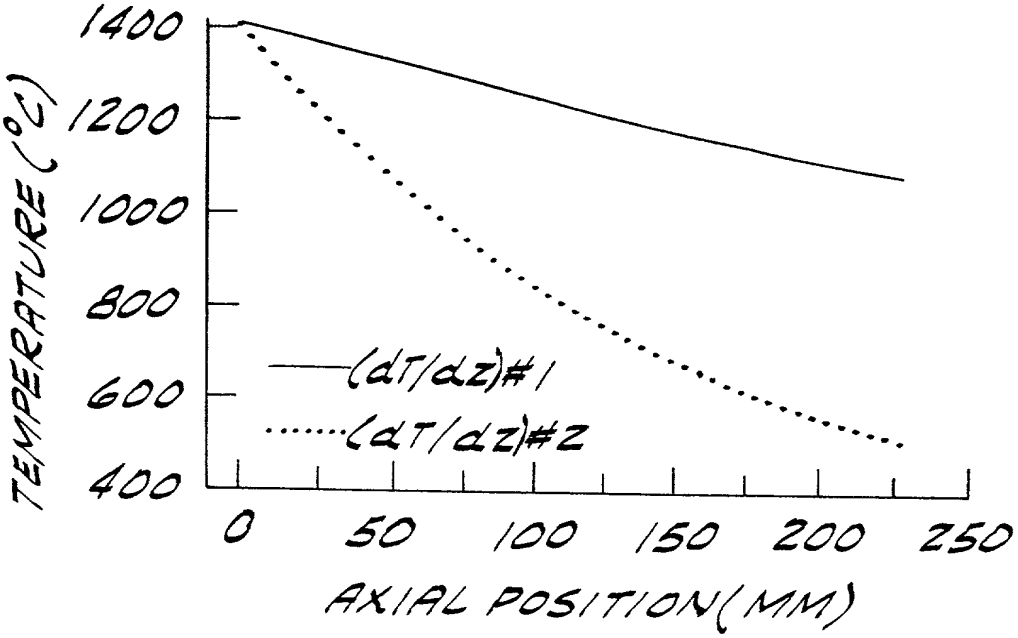

1400
1200
1000
800
600
400
TEMPERATURE (°C)
(dT/dz)#1
(dT/dz)#2
0
50
100
150
200
250
AXIAL POSITION (MM)

FIG. 13

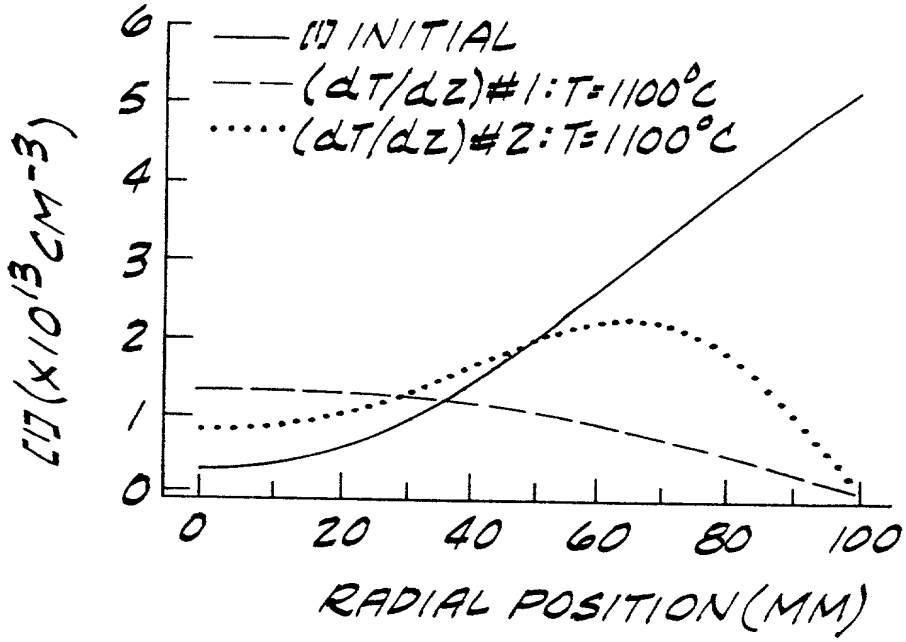
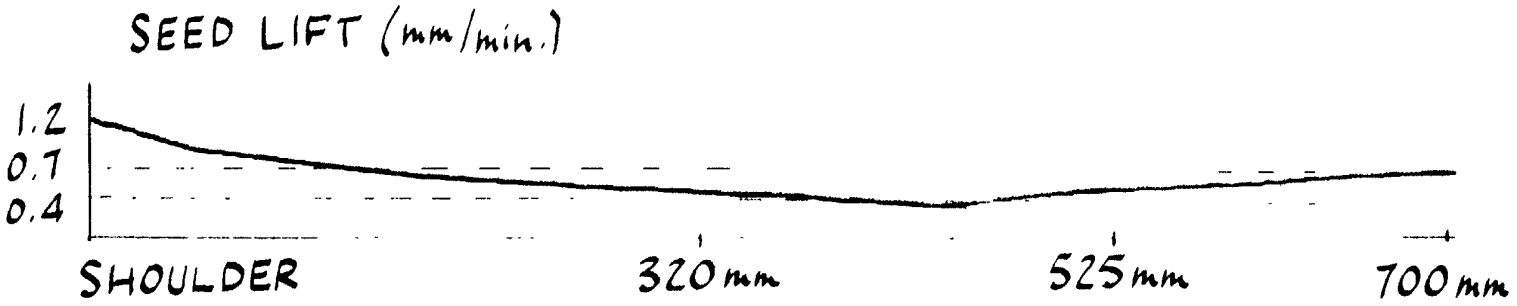

[I] INITIAL
(dT/dz)#1: T=1100°C
(dT/dz)#2: T=1100°C
[I] (X10^13 CM^-3)
6
5
4
3
2
1
0
0
20
40
60
80
100
RADIAL POSITION (MM)

FIG. 14



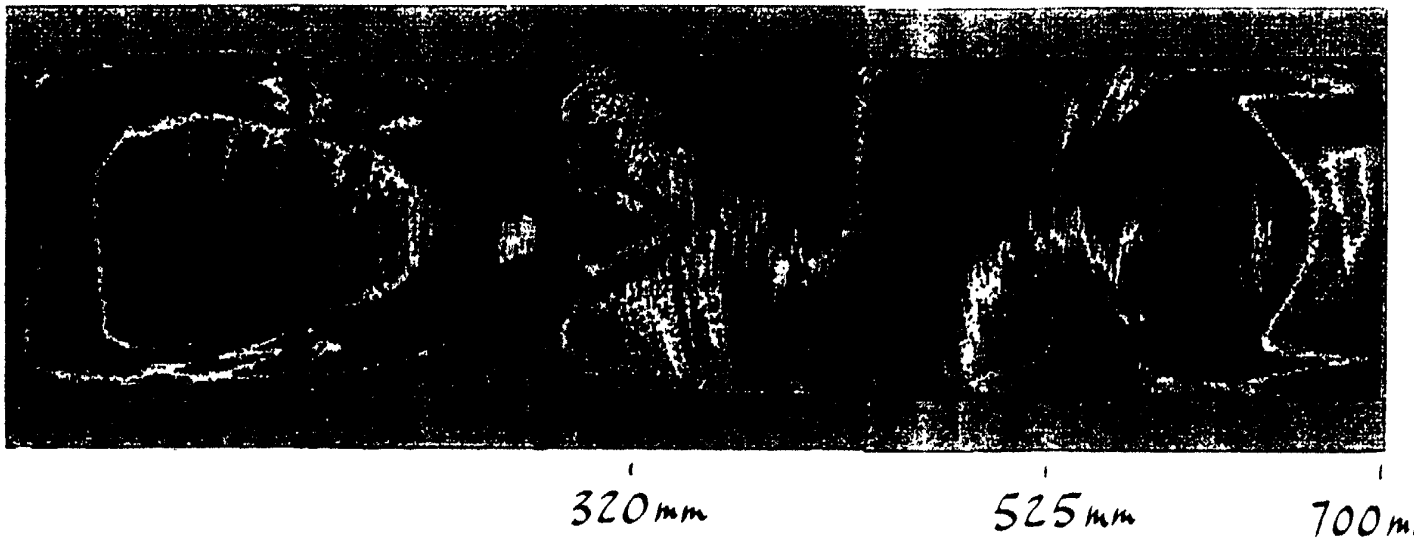


FIG. 15

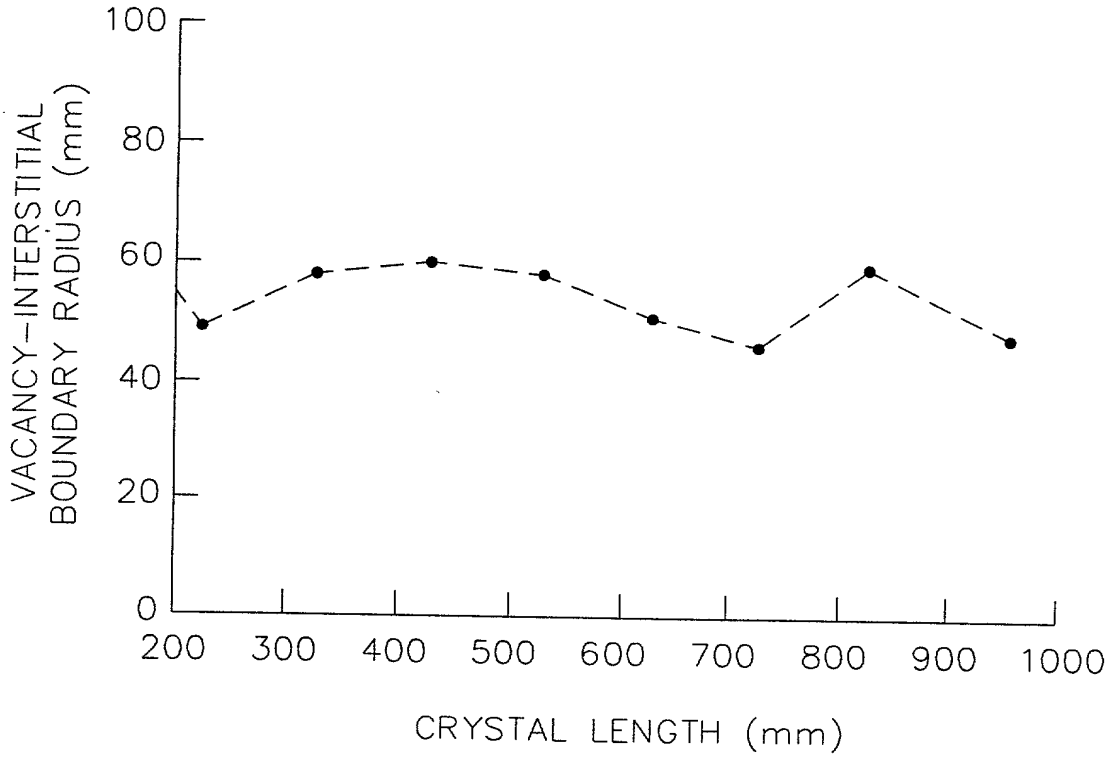

100
80
60
40
20
0
VACANCY-INTERSTITIAL BOUNDARY RADIUS (mm)
200
300
400
500
600
700
800
900
1000
CRYSTAL LENGTH (mm)

FIG. 16a

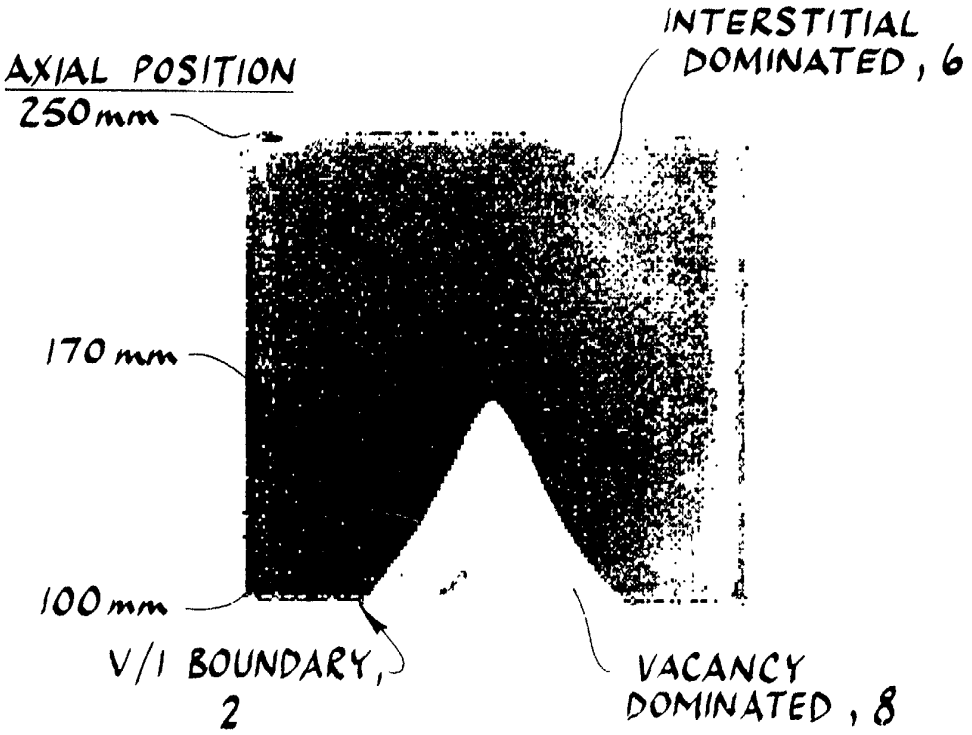

AXIAL POSITION
250mm
170mm
100mm
INTERSTITIAL DOMINATED, 6
V/I BOUNDARY, 2
VACANCY DOMINATED, 8

FIG. 16b

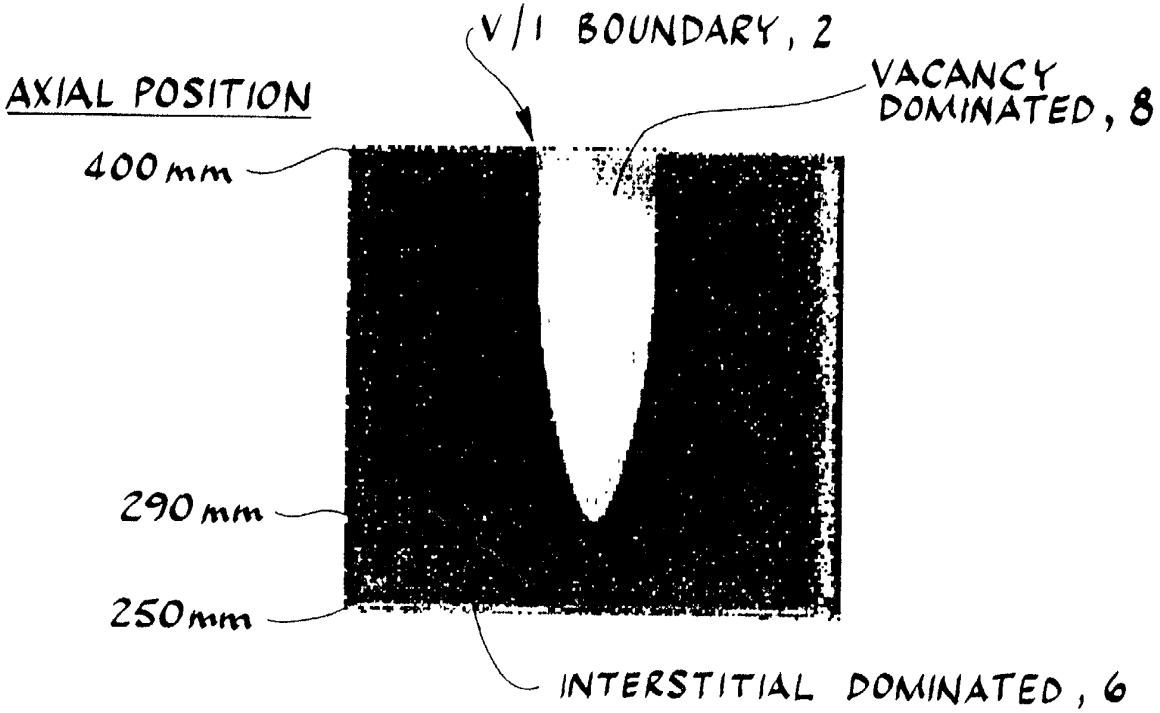

V/I BOUNDARY, 2
AXIAL POSITION
VACANCY DOMINATED, 8
400 mm
290 mm
250 mm
INTERSTITIAL DOMINATED, 6

FIG.17

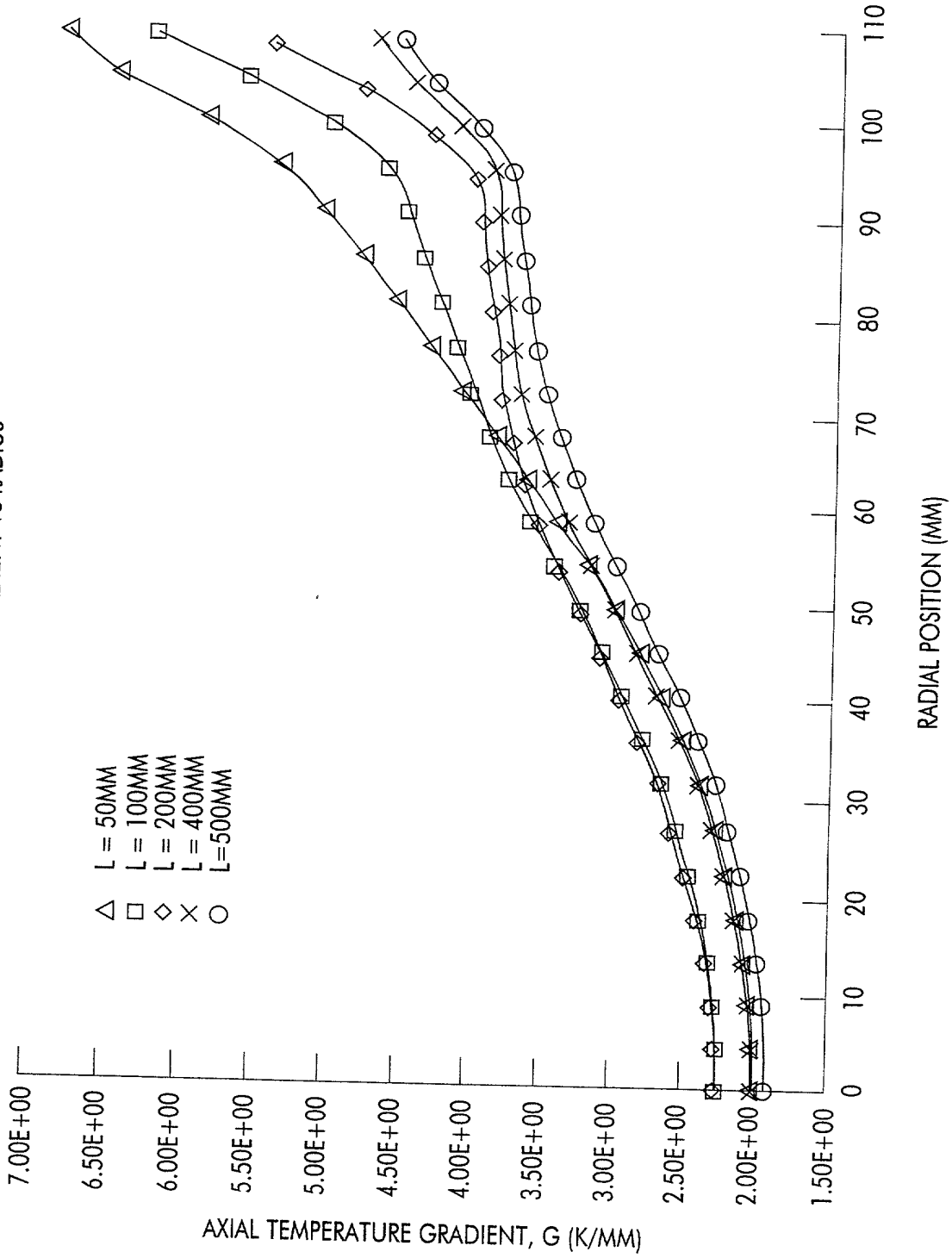

AXIAL TEMPERATURE GRADIENT VS RADIUS
L = 50MM
L = 100MM
L = 200MM
L = 400MM
L=500MM
7.00E+00
6.50E+00
6.00E+00
5.50E+00
5.00E+00
4.50E+00
4.00E+00
3.50E+00
3.00E+00
2.50E+00
2.00E+00
1.50E+00
AXIAL TEMPERATURE GRADIENT, G (K/MM)
0
10
20
30
40
50
60
70
80
90
100
110
RADIAL POSITION (MM)

FIG.18

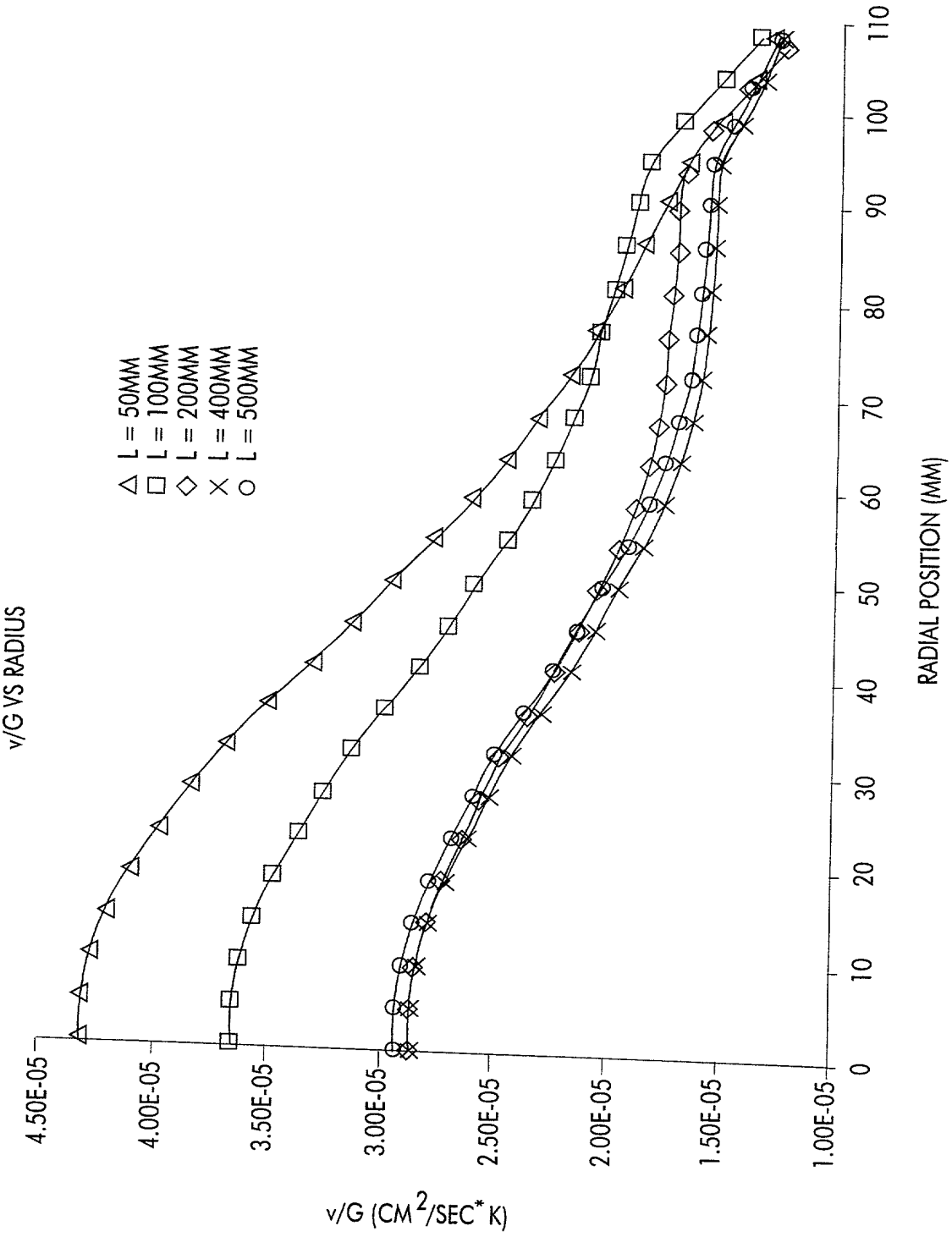

v/G VS RADIUS
L = 50MM
L = 100MM
L = 200MM
L = 400MM
L = 500MM
4.50E-05
4.00E-05
3.50E-05
3.00E-05
2.50E-05
2.00E-05
1.50E-05
1.00E-05
v/G (CM 2/SEC* K)
0
10
20
30
40
50
60
70
80
90
100
110
RADIAL POSITION (MM)

FIG.19

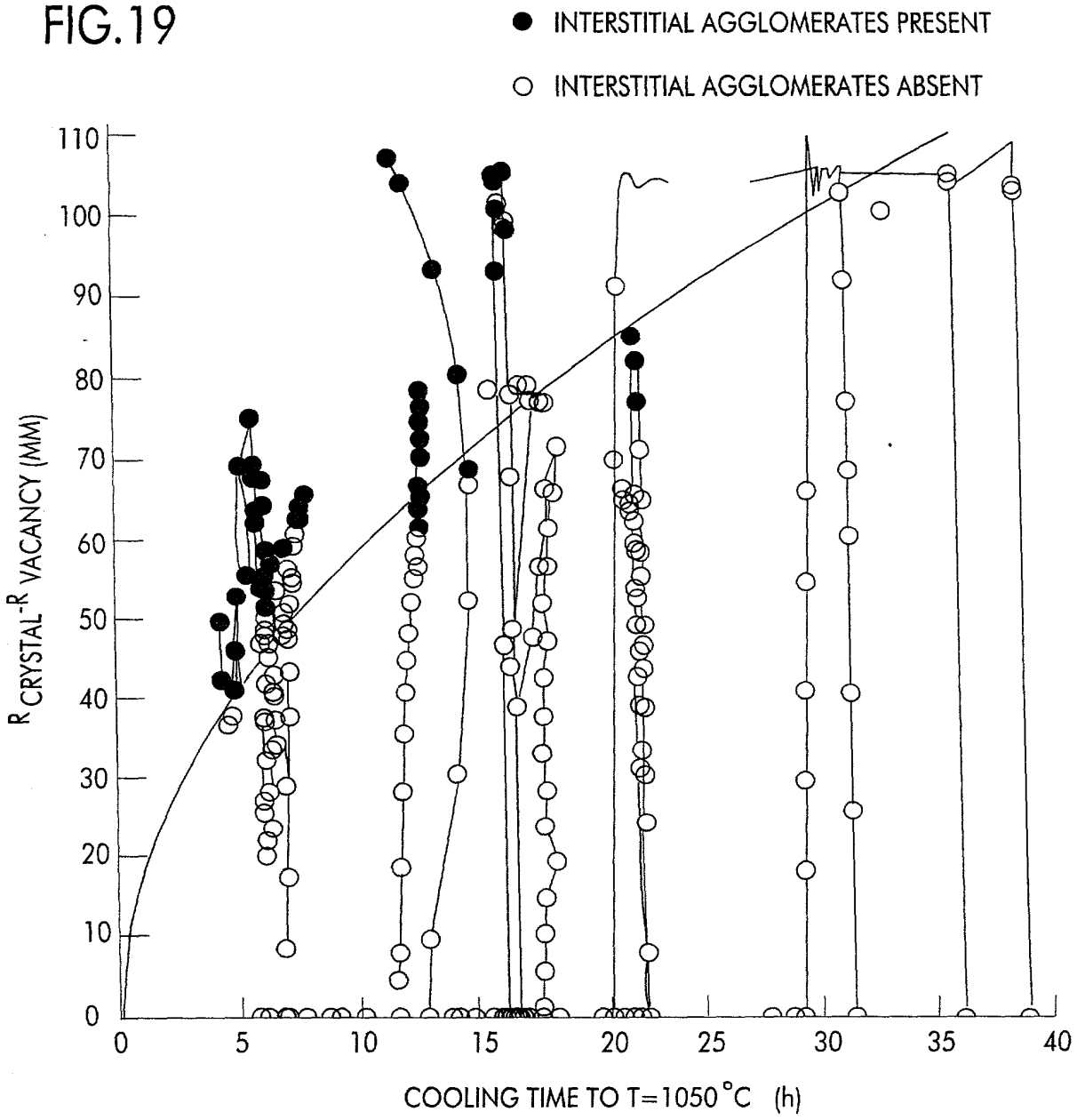

● INTERSTITIAL AGGLOMERATES PRESENT
○ INTERSTITIAL AGGLOMERATES ABSENT
110
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
40
R CRYSTAL-R VACANCY (MM)
COOLING TIME TO T=1050 °C (h)

FIG. 20

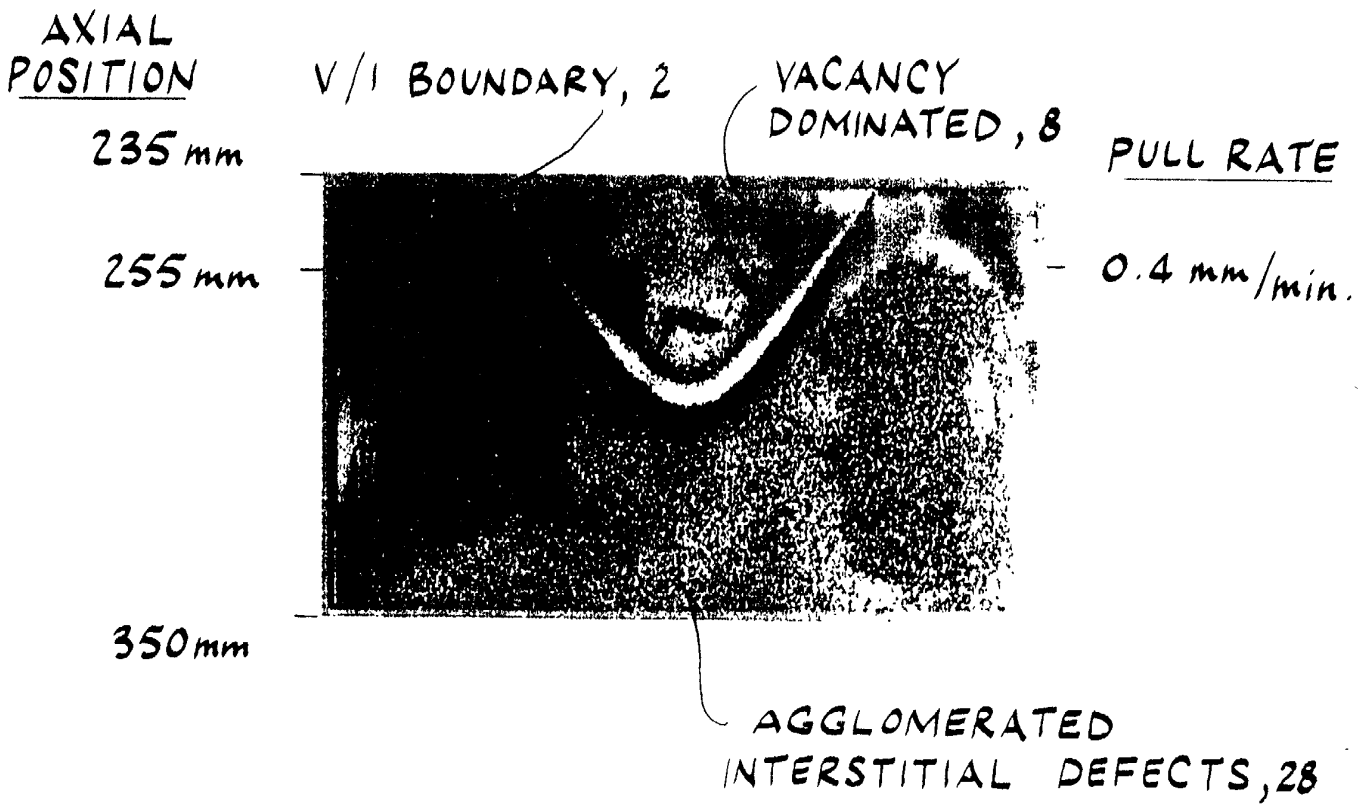

AXIAL POSITION
V/I BOUNDARY, 2
VACANCY DOMINATED, 8
PULL RATE
235 mm
255 mm
0.4 mm/min.
350 mm
AGGLOMERATED INTERSTITIAL DEFECTS, 28

FIG. 21

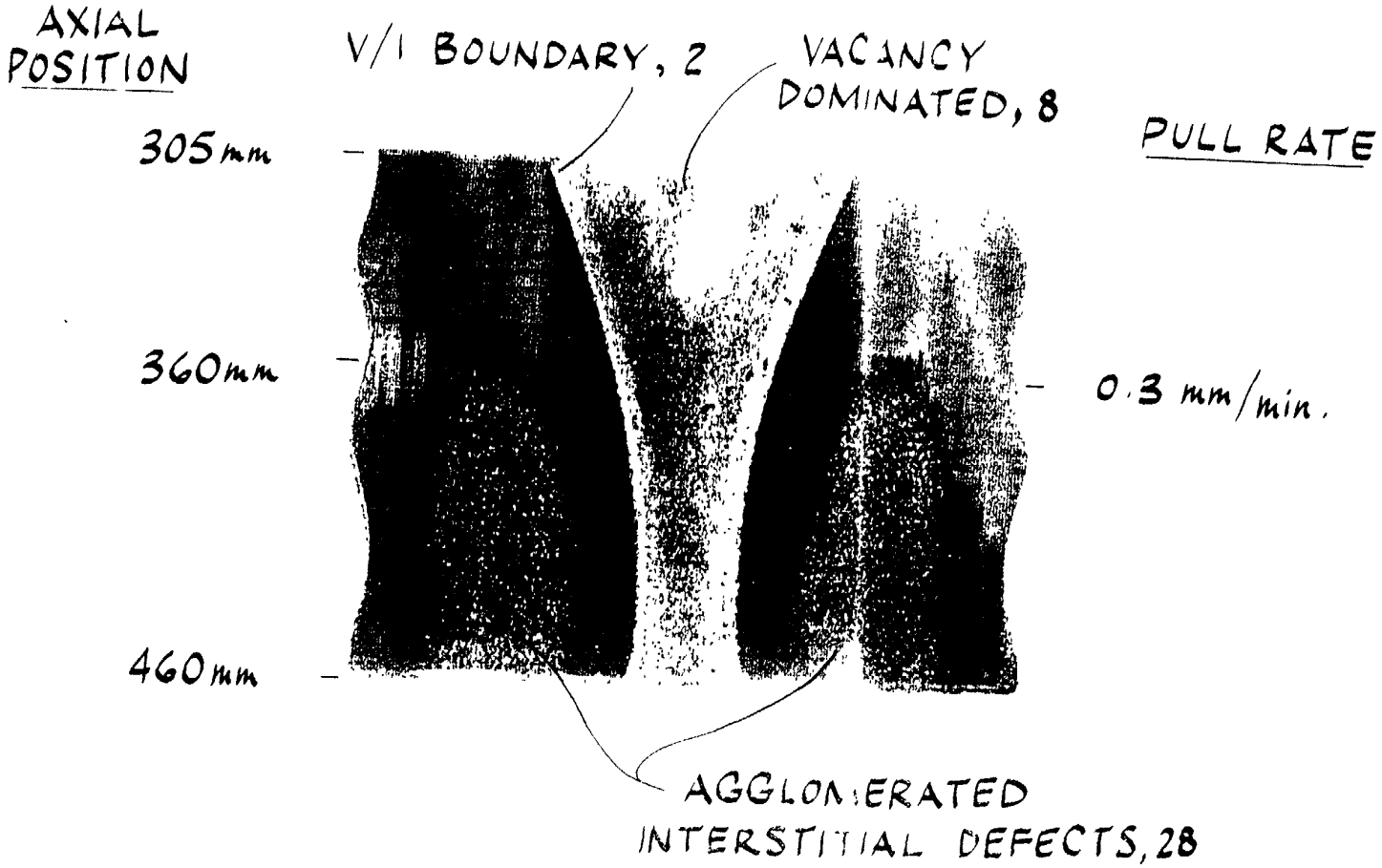

AXIAL POSITION
V/I BOUNDARY, 2
VACANCY DOMINATED, 8
PULL RATE
305mm
360mm
460mm
0.3 mm/min.
AGGLOMERATED INTERSTITIAL DEFECTS, 28

FIG. 22

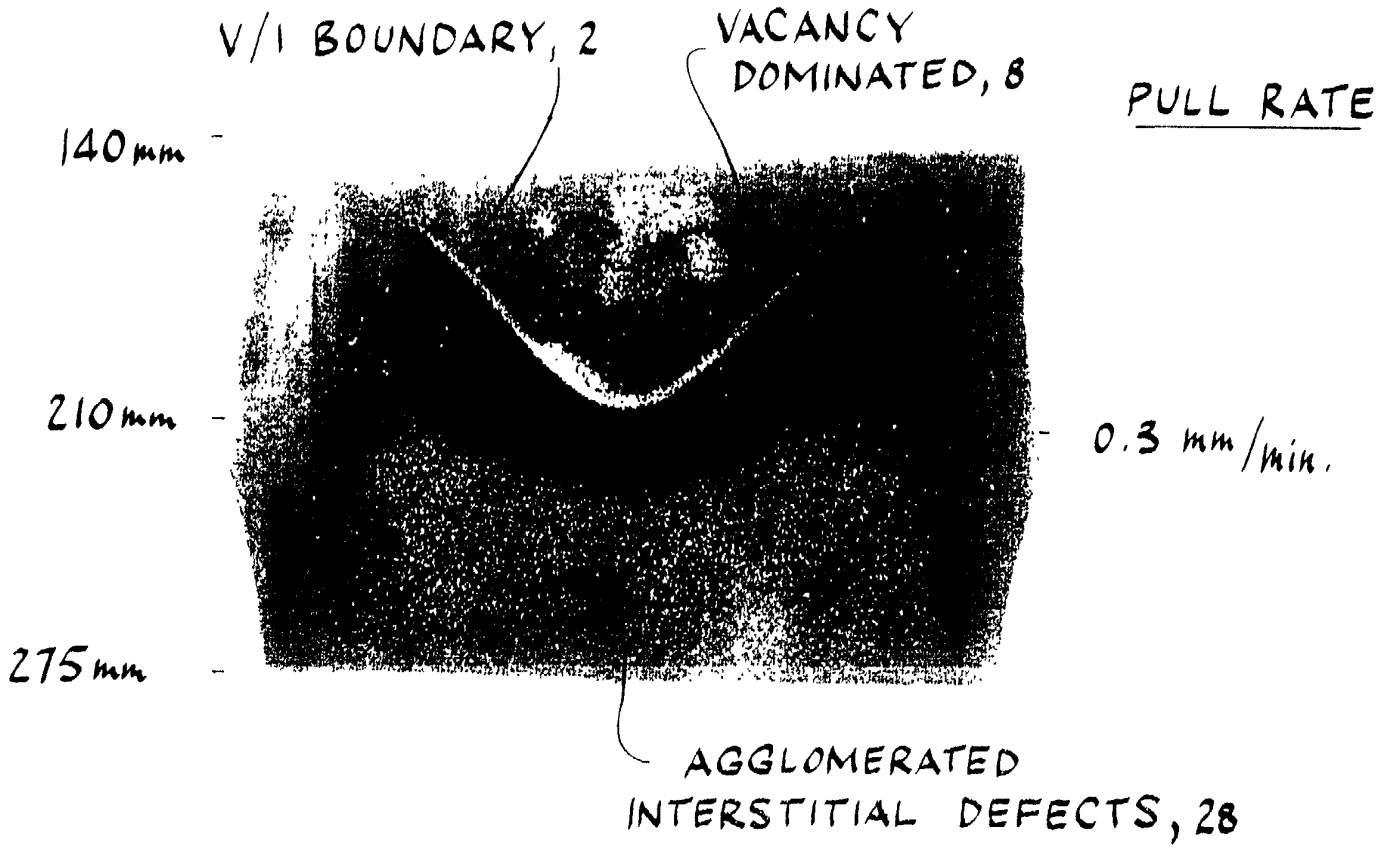

V/I BOUNDARY, 2
VACANCY DOMINATED, 8
PULL RATE
140mm
210mm
275mm
0.3 mm/min.
AGGLOMERATED INTERSTITIAL DEFECTS, 28

FIG. 23

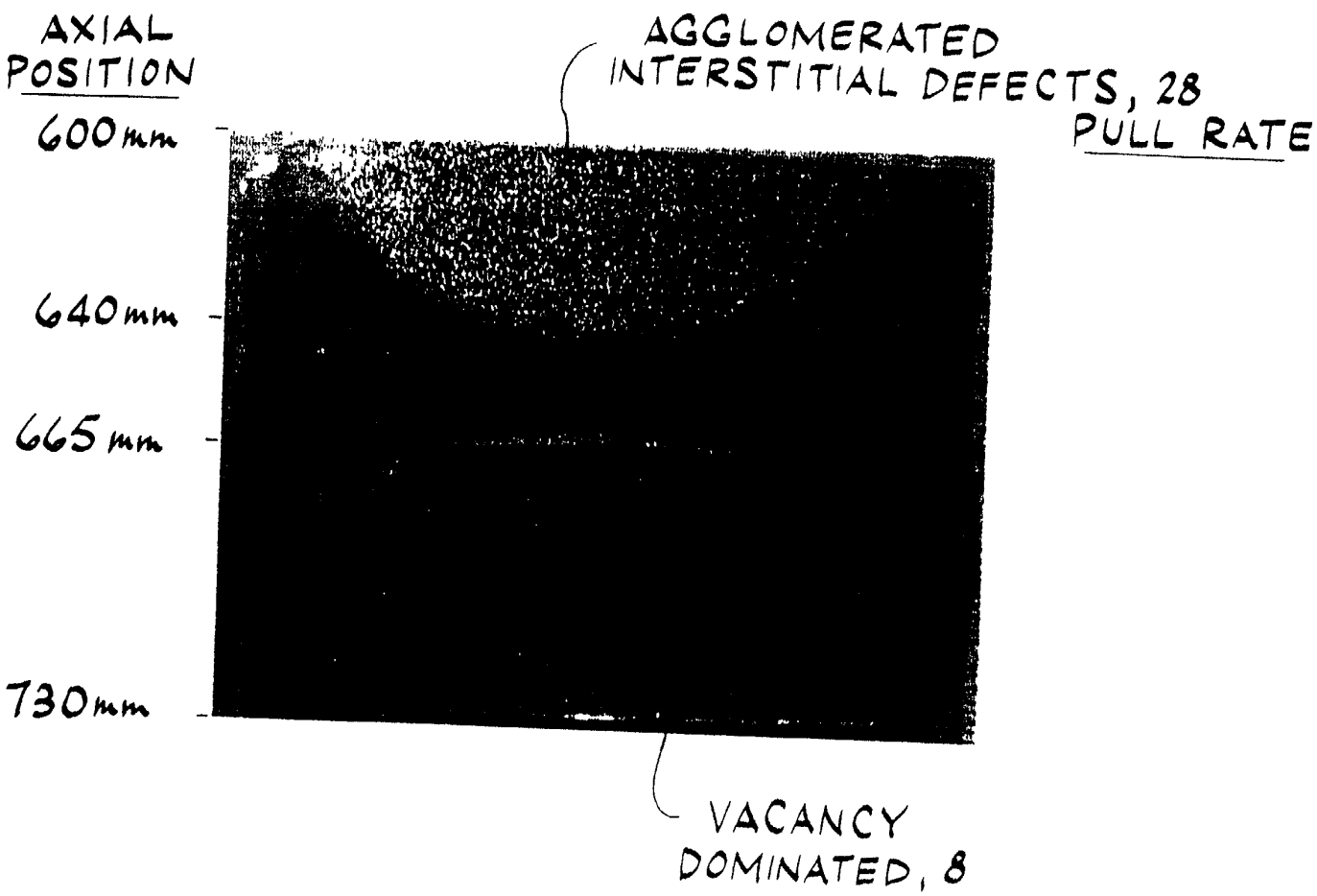

AXIAL POSITION
600mm
640mm
665mm
730mm
AGGLOMERATED INTERSTITIAL DEFECTS, 28 PULL RATE
VACANCY DOMINATED, 8

FIG.24

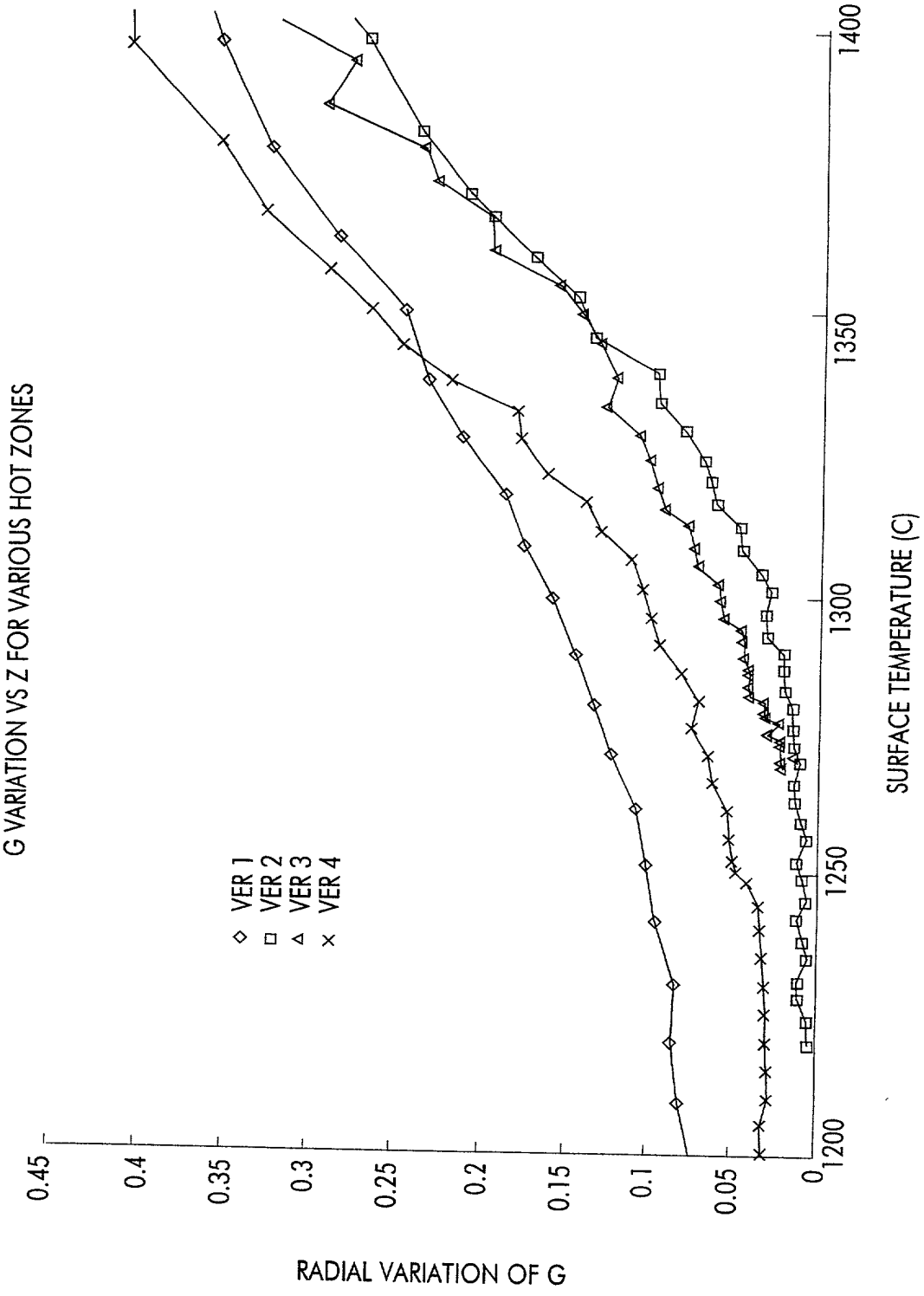

G VARIATION VS Z FOR VARIOUS HOT ZONES
VER 1
VER 2
VER 3
VER 4
RADIAL VARIATION OF G
SURFACE TEMPERATURE (C)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1200
1250
1300
1350
1400

FIG.25

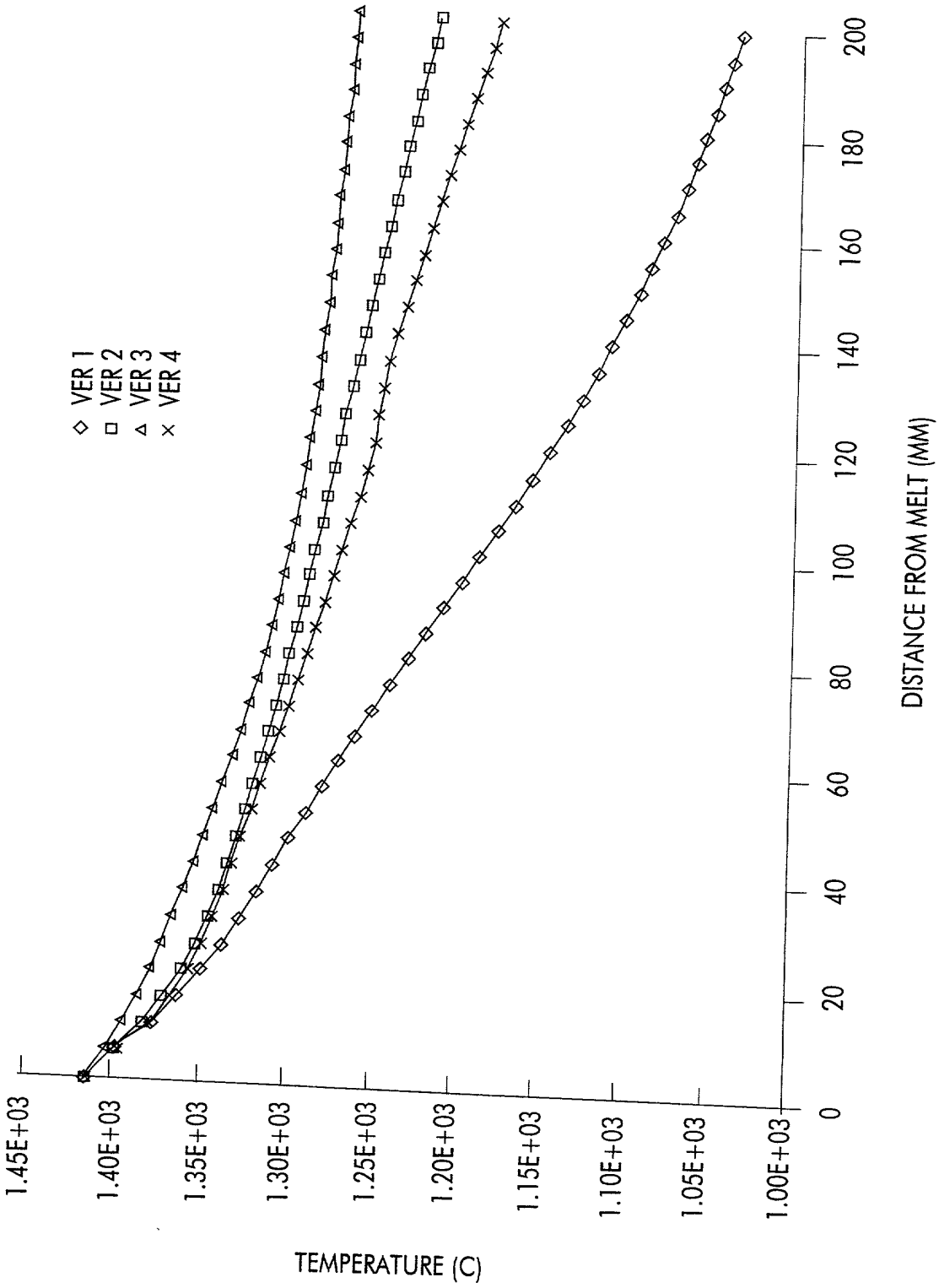

TEMPERATURE PROFILES FOR VARIOUS HOT ZONES
VER 1
VER 2
VER 3
VER 4
1.45E+03
1.40E+03
1.35E+03
1.30E+03
1.25E+03
1.20E+03
1.15E+03
1.10E+03
1.05E+03
1.00E+03
TEMPERATURE (C)
0
20
40
60
80
100
120
140
160
180
200
DISTANCE FROM MELT (MM)

FIG. 26

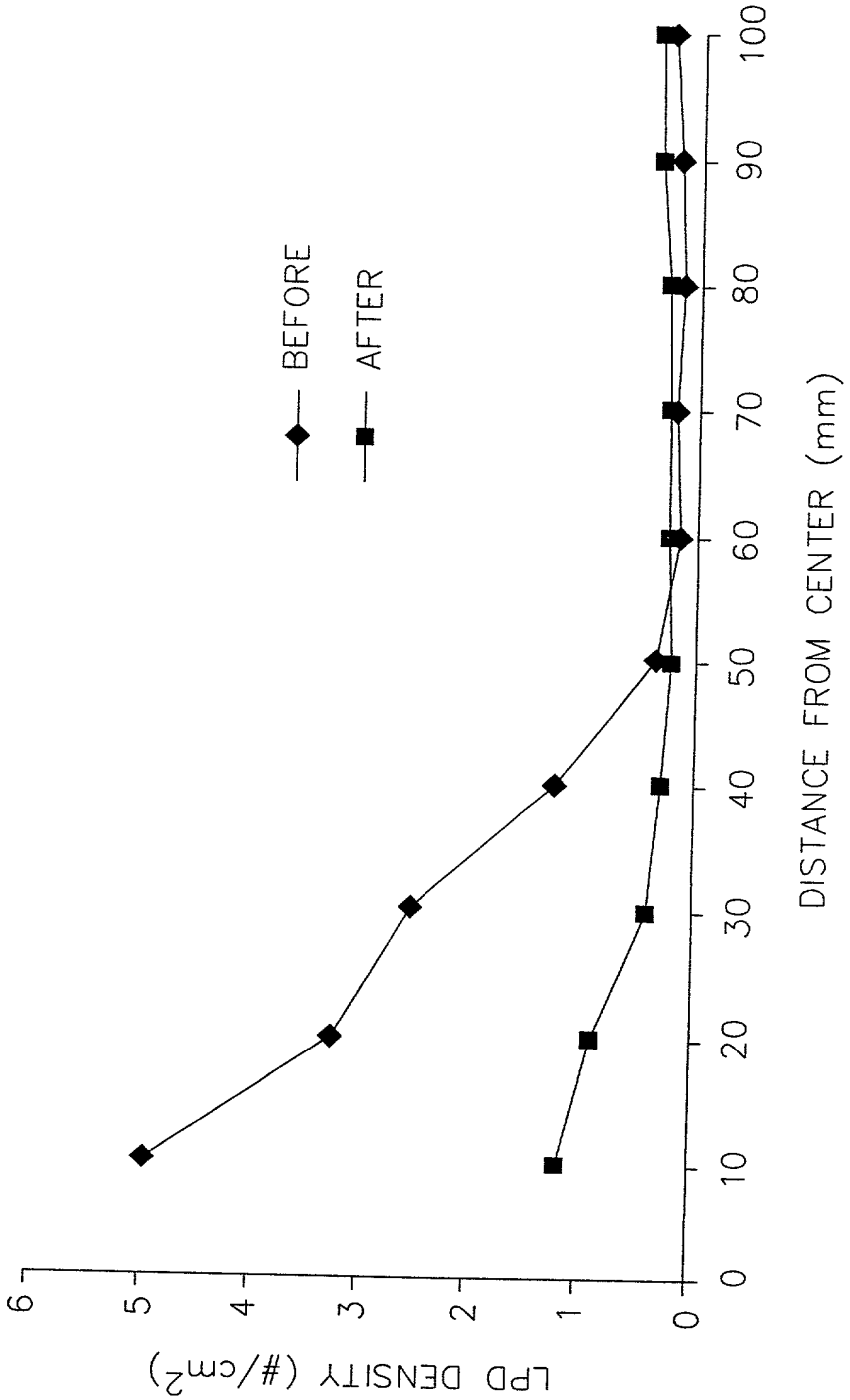

LPD RADIAL DISTRIBUTION
BEFORE/AFTER Ar ANNEALING (LPDs>0.09 um)
BEFORE
AFTER
LPD DENSITY (#/cm2)
DISTANCE FROM CENTER (mm)
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80
90
100

FIG. 27

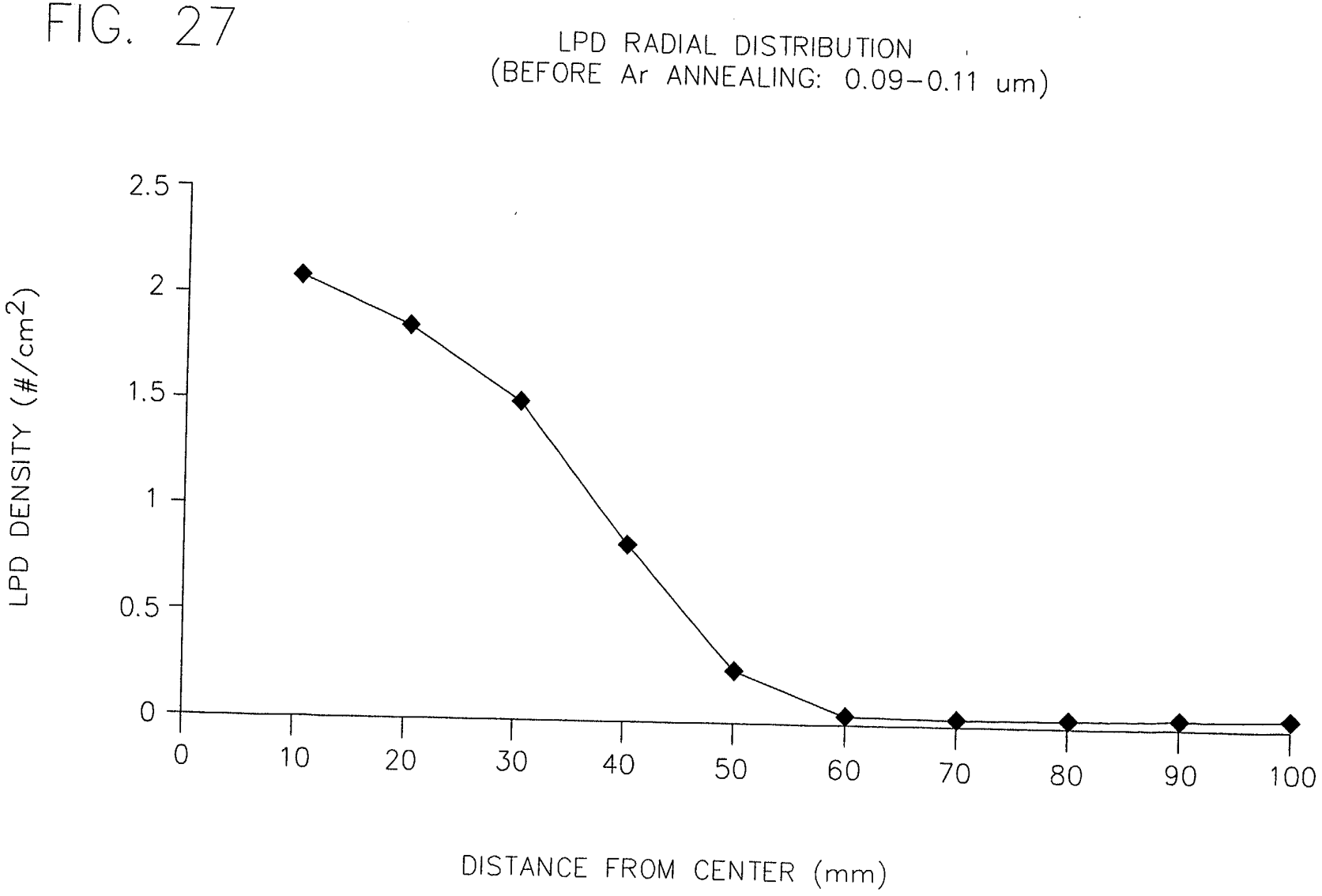

LPD RADIAL DISTRIBUTION
(BEFORE Ar ANNEALING: 0.09-0.11 um)
LPD DENSITY (#/cm2)
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60
70
80
90
100
DISTANCE FROM CENTER (mm)

FIG. 28

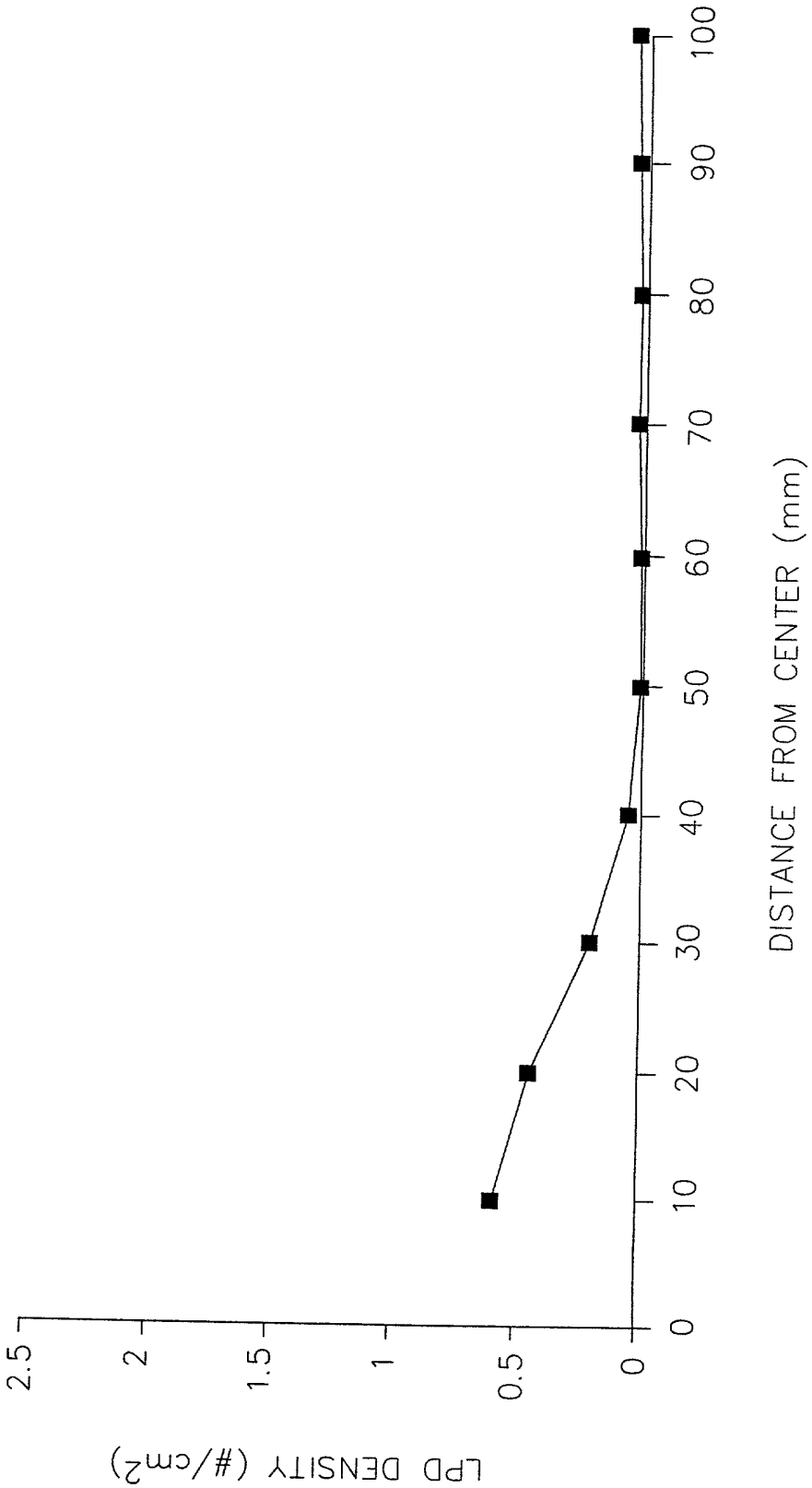

LPD RADIAL DISTRIBUTION
(AFTER Ar ANNEALING: 0.09-0.11 um)
LPD DENSITY (#/cm2)
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60
70
80
90
100
DISTANCE FROM CENTER (mm)

FIG. 29

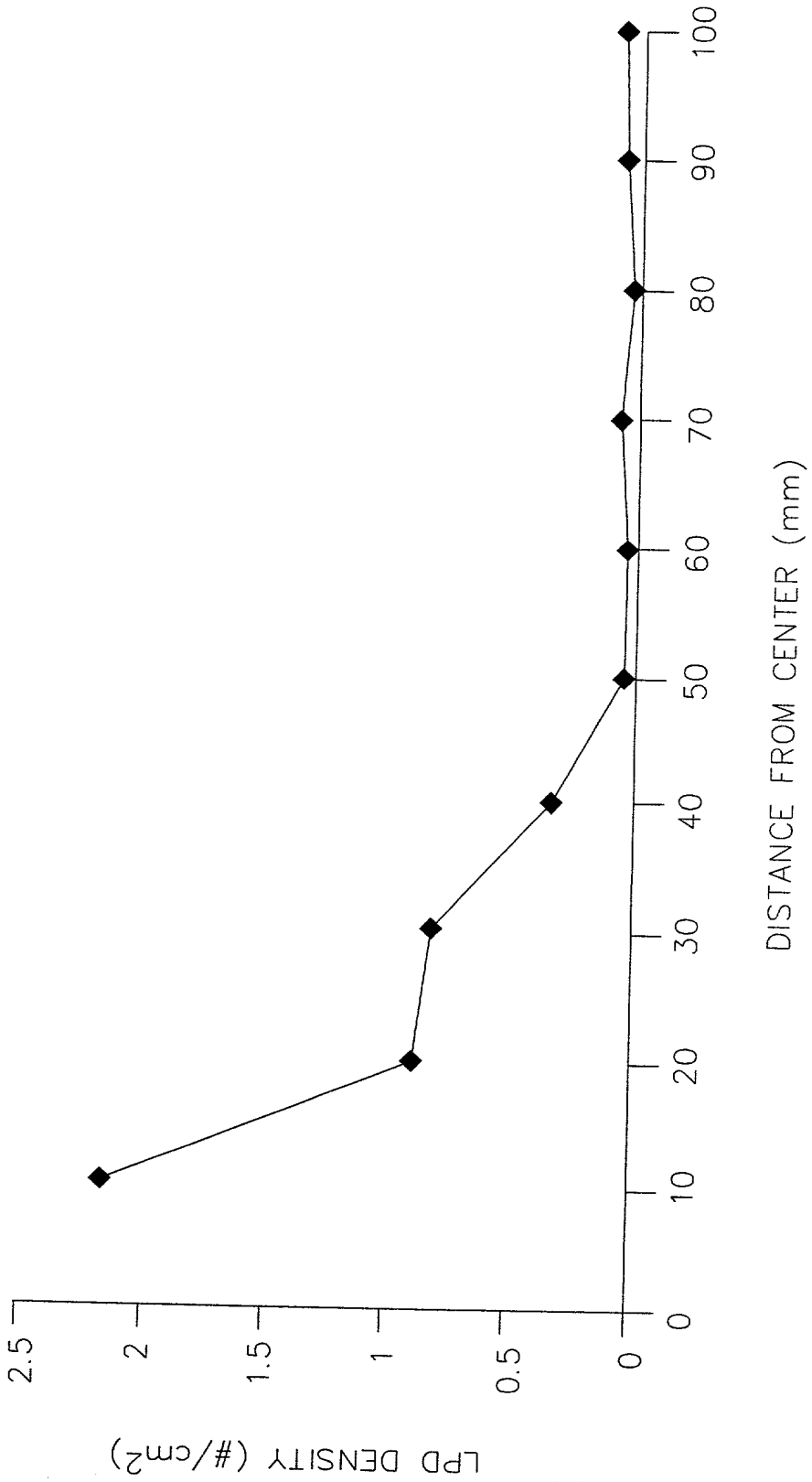

LPD RADIAL DISTRIBUTION
(BEFORE: 0.11-0.13 um)
LPD DENSITY (#/cm2)
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60
70
80
90
100
DISTANCE FROM CENTER (mm)

FIG. 30

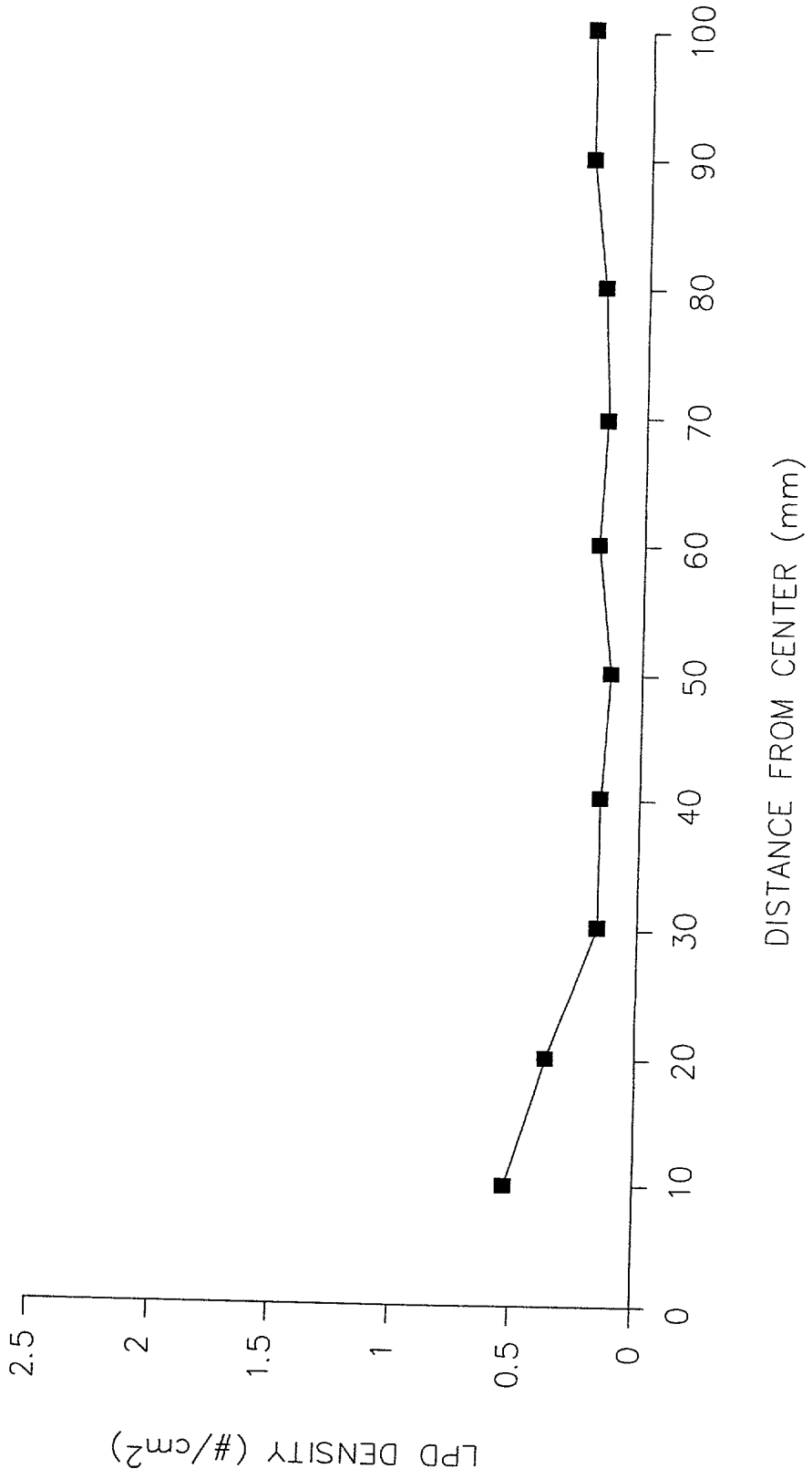

LPD RADIAL DISTRIBUTION
(AFTER Ar ANNEALING: 0.11-0.13 um)
LPD DENSITY (#/cm2)
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60
70
80
90
100
DISTANCE FROM CENTER (mm)

FIG. 31

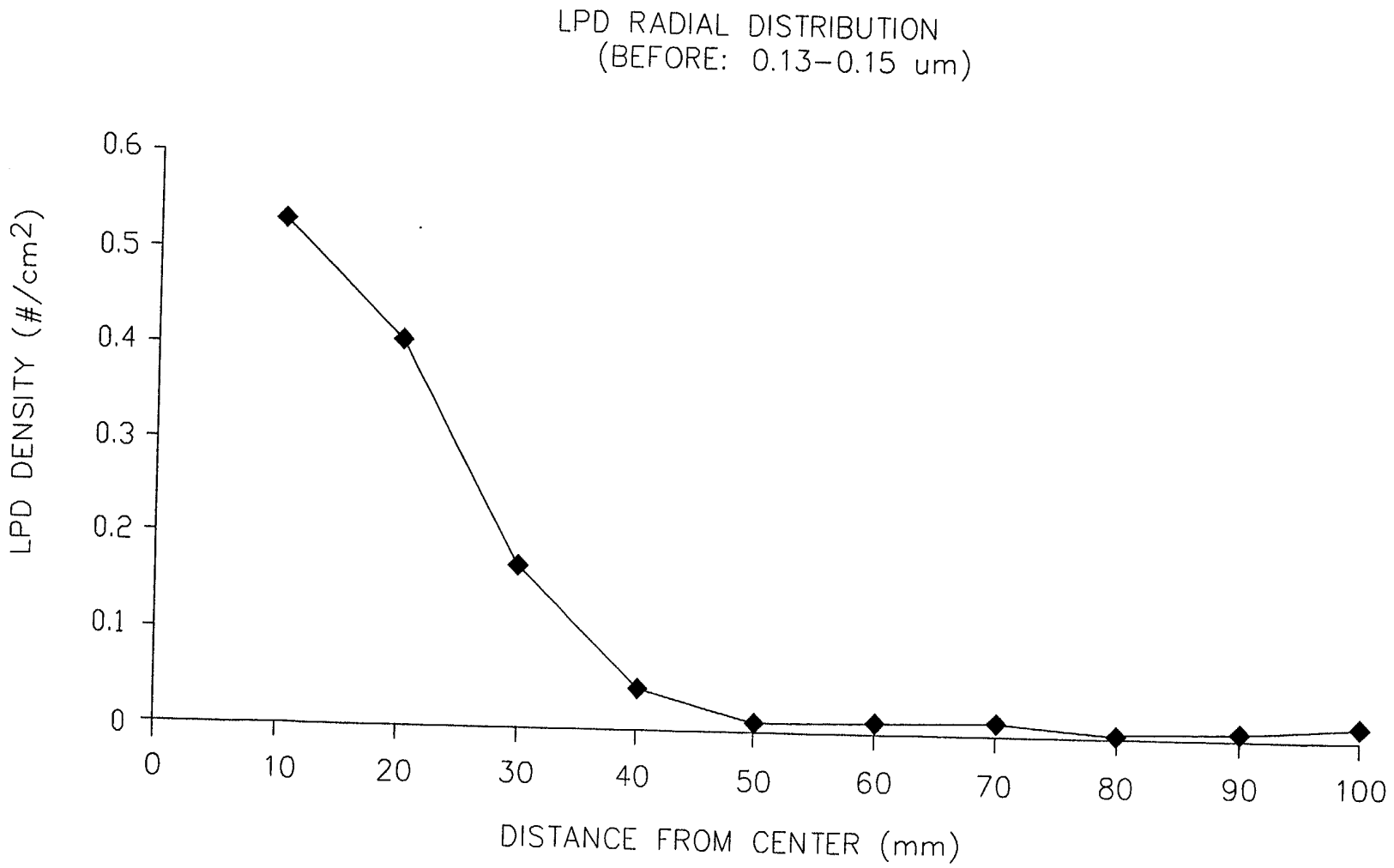

LPD RADIAL DISTRIBUTION
(BEFORE: 0.13-0.15 um)
LPD DENSITY (#/cm2)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
100
DISTANCE FROM CENTER (mm)

FIG. 32

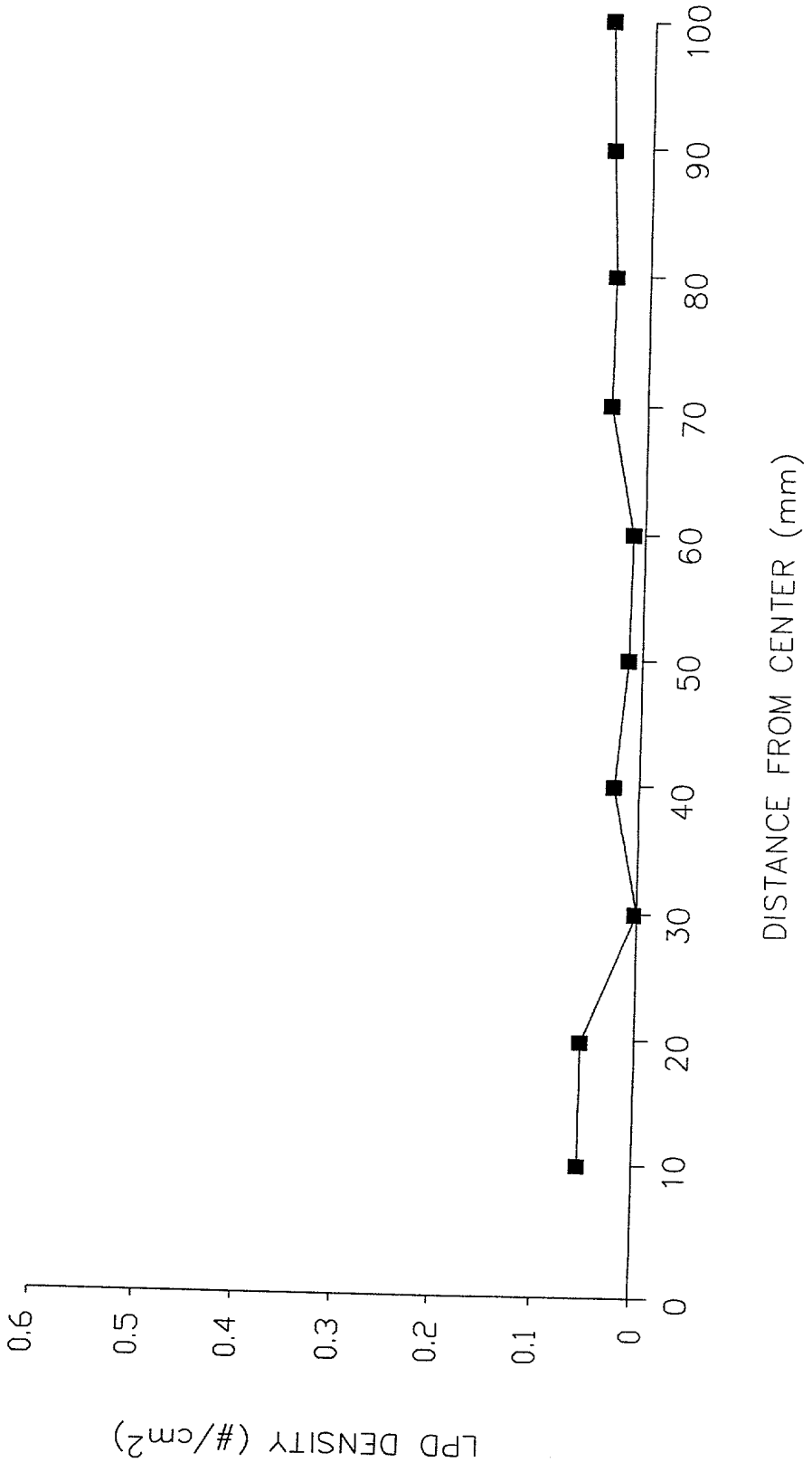

LPD RADIAL DISTRIBUTION
(AFTER Ar ANNEALING: 0.13–0.15 um)
LPD DENSITY (#/cm2)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
100
DISTANCE FROM CENTER (mm)

FIG. 33a

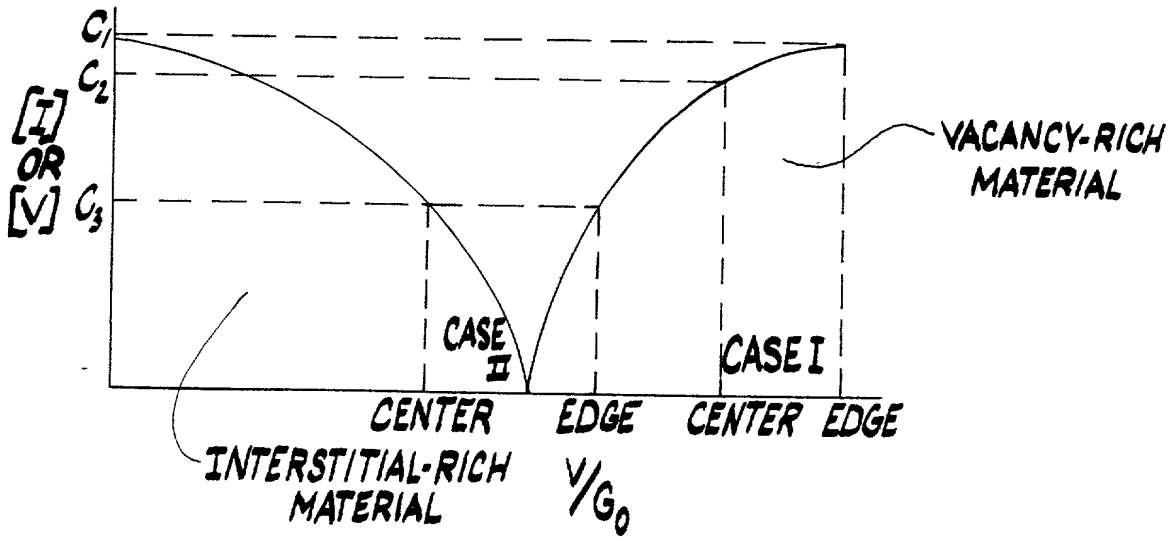


FIG. 33b

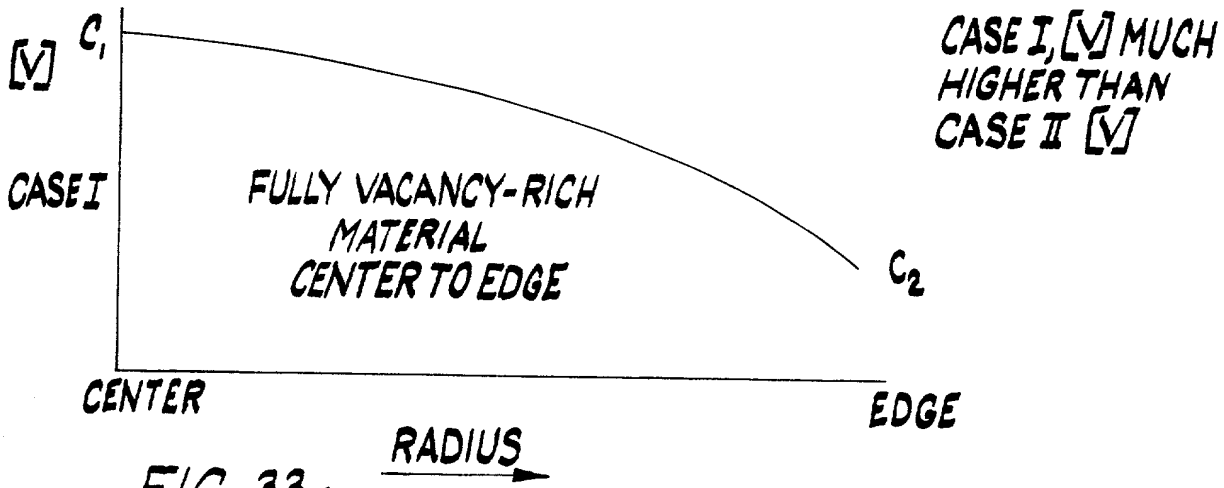


FIG. 33c